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THEIR ENGINEERING
SANITARY AND
OTHER APPLIANCES

FREDERICK COLYER
M.INST.C.E.

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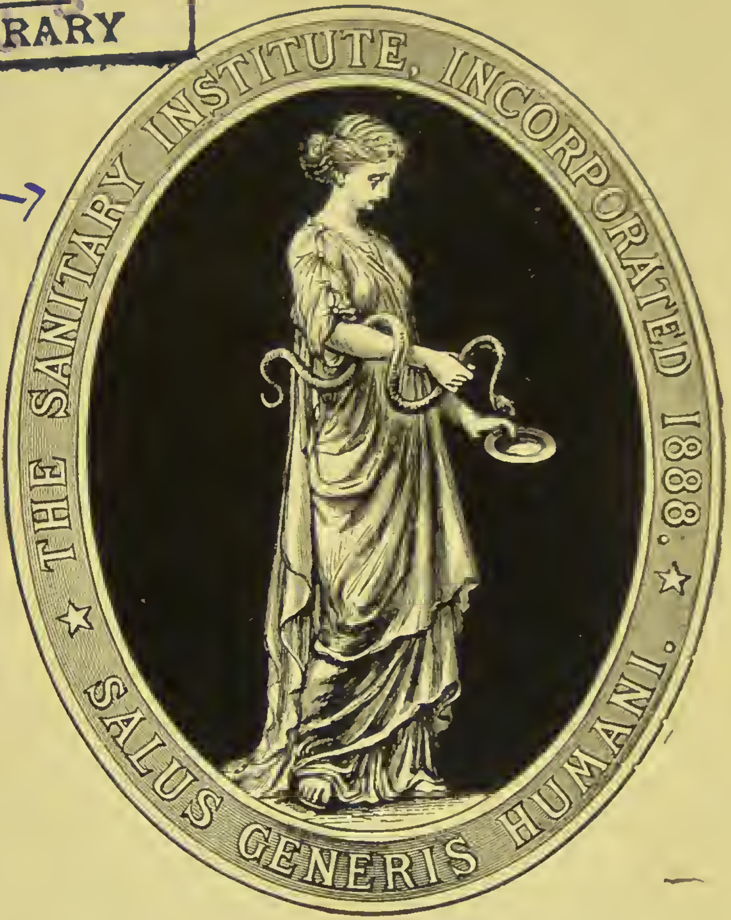

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September 1892

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THE ROYAL SOCIETY OF HEALTH

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PUBLIC INSTITUTIONS:

THEIR ENGINEERING, SANITARY, AND OTHER APPLIANCES,

WITH THE CONSTRUCTION OF SPECIAL DEPARTMENTS.

BY

FREDERICK COLYER, M. INST. C.E.,

AUTHOR OF 'BREWERIES AND MALTINGS'; 'HYDRAULIC STEAM AND HAND-POWER LIFTING AND PRESSING MACHINERY'; 'PUMPS AND PUMPING MACHINERY'; 'GAS-WORKS CONSTRUCTION'; 'WORKING AND MANAGEMENT OF STEAM BOILERS'; 'MODERN STEAM ENGINES AND BOILERS'; 'WATER SUPPLY, DRAINAGE, &C., OF RESIDENCES.'

E. & F. N. SPON, 125, STRAND, LONDON.

NEW YORK: 12, CORTLANDT STREET.

1889.

PREFACE.

I HAVE been asked to write a description of engineering and mechanical fittings as applied to Public Institutions, such as Asylums, Schools, &c., also as to the proper construction of the buildings. Having lately offered a smaller book to the profession treating upon kindred matters, more especially relating to "Residences and Mansions," I have endeavoured to repeat as little as possible of what I have previously said. Many matters described in the book referred to are also applicable to the large institutions now treated, but altered in some details to suit the particular cases under consideration.

I have written this book with a desire to give all necessary information to architects and surveyors engaged in these large constructions, and have given the results of my own practice in such matters, as well as that of other specialists who have favoured me with data.

As some architects may not be acquainted with

the firms best suited to carry out some of the special works described, I have named in several cases those whom I have often employed with advantage.

I fear the book may be faulty in many respects. I shall be glad to receive any suggestion from my professional brethren for additions and improvement in a future edition.

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Civil Engineer and Architect.

18, GREAT GEORGE STREET, WESTMINSTER, S.W.
February 1889.

SYNOPSIS.

CONTENTS.

CHAPTER I.

INTRODUCTION.

CHAPTER II.

SANITARY APPLIANCES.

CHAPTER III.

DRAINAGE AND SEWAGE DISPOSAL.

CHAPTER IV.

WATER-SUPPLY—COLD AND HOT SERVICE.

CHAPTER V.

WARMING APPARATUS.

CHAPTER VI.

LIFTING MACHINERY.

CHAPTER VII.

COOKING APPARATUS AND BAKERY.

CHAPTER VIII.

STEAM LAUNDRIES.

b

CHAPTER IX.

ENGINES, BOILERS, AND PUMPING MACHINERY.

CHAPTER X.

STABLES, COW-HOUSES, AND WORKSHOPS.

CHAPTER XI.

GAS WORKS AND LIGHTING.

CHAPTER XII.

BREWERIES.

CHAPTER XIII.

ELECTRIC LIGHT PLANT.

PUBLIC INSTITUTIONS:

THEIR

ENGINEERING, SANITARY, AND OTHER APPLIANCES.

CHAPTER I.

INTRODUCTION.

In a work lately offered to the profession, 'Water Supply, Drainage, and Sanitary Appliances of Residences,' the author touched upon many points that apply to the matters under present consideration. As some of the apparatus and appliances therein described may be suitable for small institutions, it is advisable that the reader should consult that work as well as the present one. In this treatise, it is proposed to take all the leading important constructions, also the sanitary, engineering, and other arrangements that are required in large places, such as schools, asylums, unions, hotels, &c.; to treat each department of the subject in detail, and to indicate the most modern and desirable way in which to carry out the necessary works. In some of the special departments the construction and proper dimensions of the buildings will be fully treated, and sufficient

details given to indicate the best manner to erect them suitable for their special purpose. The general methods of construction are laid down for cases most likely to arise; it would be impossible to give details to meet every special circumstance.

The subject will be divided into the following main heads:—

Sanitary appliances, Baths and Lavatories, &c.
Drainage and sewage disposal.
Water supply—hot, cold, and rain water.
Heating apparatus.
Lifting machinery.
Cooking—kitchen apparatus and bakeries.
Steam laundries.
Engines, boilers, and pumping machinery.
Stables, cow-houses, piggeries, &c.
Gas-works and plant.
Breweries and plant.
Electric light machinery and plant.

These heads will be again subdivided, to give details of all matters connected with each.

The fittings, &c., for the officers' residences, should be carried out in the manner described in the author's book above alluded to. Except as regards hotels and establishments of like kind, the appliances treated will principally be those applicable to public asylums, schools, &c.

The subject is a large and somewhat difficult one to treat; the author intends to address himself

principally to architects and surveyors who may want technical assistance; it may also be found useful to managers and proprietors of large places, to indicate the arrangements that should be made for successfully carrying on their establishments. The author having often been called in to advise architects, &c., believes the information contained may be useful to them, as all the work described is either from his own experience in carrying out works for himself and the profession, or the result of what he has seen in successful working at large institutions, and from information kindly furnished him by the engineers and surveyors of those places. He takes this opportunity of thanking more particularly Mr. H. Martin, C.E., the engineer and surveyor of the Middlesex County Asylum, Hanwell, for the valuable information and data he has received on several occasions from him. It will be understood that the manner of carrying out work herein described is not in any way theoretical, but the result of successfully accomplished works that have borne the test of use for some period.

The subject of proper drainage and water supply is of the greatest importance to ensure the health and comfort of the inmates; it is to be feared these matters have not always received the skilled attention they deserve, and that their neglect has in too many cases been most prejudicial to health, and the cause also of even more serious results. In carrying out this class of work, the most intelligent supervision is

needed from clerks of works and foremen; it also requires the personal attention of the architect and engineer to the details to ensure perfect work. A proper system of warming and ventilation is an equally important thing. Several systems of warming will be described, some of which may be more suitable under certain conditions than others; much blundering has taken place over this kind of work, and in many cases it has been carried out in a very inefficient manner, and has proved in after working very costly. The two subjects of warming and ventilation must always be considered together, as it is impossible to warm a place properly and make it healthy without a proper system of ventilation. Kitchen apparatus, laundries, engines, and boilers, also require special attention. The author here suggests the advisability of the architect in all large cases taking the advice of a consulting engineer, and placing in his hands the preparation of the general scheme for all the leading appliances named. He would then be able to make the needful preparations in his building for the work, and thus ensure that all important things had received the care and attention they deserve. The disposition of the various plant and appliances in reference to each other, and to ensure that a suitable locality has been chosen, would save the serious errors into which too many have fallen by non-attention to this.

In several instances the author has found the boilers and engines and some of the machinery most

inconveniently placed with regard to the machines, &c., they have to supply and drive. Boiler shafts should be provided suitable for the boilers they have to serve; in some instances they may be carried up with the walls of the building, and much expense saved. Means of communications to various parts of the building, such as electric bells, telephones, speaking tubes, &c., are an essential for the easy working of all large places.

With regard to the system to be adopted for lighting, the electric light has been making rapid advances towards greater perfection; it becomes a question for consideration, whether in many cases it may not be the most advantageous means of lighting as far as the comfort and health of people are concerned. For all isolated places, and also those which have steam-power on the spot, a special plant should be put down; the whole system is then under proper control, and there is little or no risk as to the failure of the supply.

Where gas lighting is adopted, and where a supply cannot be obtained from any gas-works near, works and plant should be laid down in the manner hereafter described. These works must always be constructed to admit of future extensions should the necessity arise.

There are many other minor fittings requisite for these establishments that cannot be noticed within the compass of this work; they are, however, not material. It is quite possible too much detail of

what may appear of a rudimentary character has been given; if so, the author trusts he will be pardoned by those who are well acquainted with such matters. The object is to help those who require it, and to do it in simple and short language, which in these days of hurry seems the only form acceptable to busy men. As much as possible, repetition will be avoided, and each section kept separate; in some instances it will not be possible to carry out this in subjects intimately connected, especially with regard to drainage and sanitary work. With regard to engines, boilers, and pumping machinery, as well as lifting machinery, reference is given to special books on these subjects; this book, however, comprises, most of the cases likely to arise in an architect's practice.

CHAPTER II.

SANITARY APPLIANCES.—WATER CLOSETS, BATHS, LAVATORIES, SINKS, Etc.

The internal work suitable for residences and large mansions has been fully described in the Author's book named at p. 1. It is not intended to repeat more of these details than is necessary for the institutions under consideration. It may be preferable to adopt the system in the book named, of describing the fitting-up of water closets, urinals, sinks, lavatories, baths, &c., before entering on the subject of drainage; as it will then be more clearly understood the purpose the drains have to serve.

Water Closets for Asylums.—These have to be fitted up in accordance with the requirements of the Lunacy Commissioners; the number for each ward is, as a rule, regulated by them, and also their position. The best closets are the Valve kind, the discharge from the pan and the water supply being made self-acting by the opening of the door of the room. When the closets are placed on an upper floor, or on the ground floor with a basement under, a lead safing 6 lb. per superficial foot should be fixed under each pan, with a $1\frac{1}{2}$-inch diameter lead drain pipe in

the corner to carry away any waste water. The soil trap directly under the syphon should be made of solid drawn lead 8 lb. per superficial foot; it should be brought through the safing and flanged over it. The flange of the syphon on the pan should be jointed to it, and screwed through to the boards or timbers of the room. The soil pipe should be of solid drawn lead 8 lb. per superficial foot fixed *outside* the building, the top of which should be taken up above the roof for ventilation, and fitted with Banner's Patent Cowl. The number of closets on the same level taken into one soil pipe must depend upon the circumstances of each case. For a single closet the diameter of the soil pipe may be $3\frac{1}{2}$ inches; for two, 4 inches; four, 5 inches. The pipe should be supported at every 5 or 6 feet by double lead tacks 9 to 10 lb. per superficial foot; the discharge of the soil should be into a receiver which is disconnected from the main drains; this will be described hereafter. A 2-inch diameter ventilating pipe must be attached to the top of the lead trap, to take off any sewer gas that may collect at this point, and may be connected into the large ventilating pipe. In cases where say three closets discharge into one soil pipe, those on either side should enter by pipes set to a sharp fall, and made to join the main pipe by easy curves. The water supply pipe should be lead $1\frac{1}{2}$ inch diameter, to afford a good flush to the pan and trap. The enclosure, riser, and seat may be made of deal, the seat and front of the riser made to open for cleaning and examination.

The walls of the rooms may be lined with plain white glazed tiles, and the floors covered with red and black tiles. A ventilator should be placed in the outer wall of the room. When it is possible to arrange it, the closets should not open direct into the passage, but into an intermediate lobby, which should be well ventilated, and thus save any bad air from the closets being taken into the passages or rooms. The closets are best placed in clusters or sets at convenient parts of the place. The size of the rooms should not be less than 3 feet wide by 5 feet long and 8 feet high. Permanent ventilation to the outer air direct should always be provided.

Water Closets for Hotels.—These should be fitted up in the manner described in the former book for private residences. When two or more are placed in a set on the same level, the soil pipes may be arranged in the same manner as at p. 8. The ventilation should not depend upon any window, but there should be ventilators in the outer wall, permanently open. When the closets are placed on the different floors, one above the other, great care must be taken that the lead traps under each of the pans are so arranged that they cannot become unsealed. The walls of the rooms should be covered with glazed tiles, and the floors paved with tiles. The size of the rooms should not be less than 3 feet 6 inches wide, by 5 feet 6 inches long, and 8 feet 6 inches high.

Water Closets for Schools, Workhouses, &c.—A good form is made by Mr. George Jennings. The pans are made large; they all communicate with a lower pipe which receives the soil; this is flushed out by a syphon at certain periods. The divisions between each of the closets should be made of slate slabs about ¾ inch thick; these are let into the brick-work of the back wall, and into grooved cast-iron posts in front; on these posts wooden doors are hung. Each closet should not be less than 3 feet wide by 4 feet deep, and 7 feet 6 inches high. The roof may be formed of slate slabs, provided with a lantern or dormer for light and ventilation. Cement concrete should be placed under the floor, and the paving laid with Stuart's patent granolithic cement. The back and ends of the range of closets should be built in brickwork, the interior being lined with glazed bricks. The place can readily be kept clean by this form of construction.

Water Closets for "Unions" and Factories—Out-door.—These may be constructed of the same size as those named above, the pans and troughs are made in a special manner, the soil falls into an open trough of glazed earthenware, connecting all the closets in the same set. A self-acting Field's patent flushing tank is provided to serve all the closets. The inlet of water is adjusted to allow it to be automatically discharged at regular periods; this, however, is not under the control of those who use

the place. They are cleanly, and for out-door work are very suitable for the purpose indicated. The trough is discharged through a syphon trap into the main soil drain pipes. A ventilating pipe should be fixed at the top of the syphon, to take off the sewer gas; an air inlet should also be provided.

URINALS.

Urinals for Asylums and Unions.—These should be divided by slate slabs into separate stalls of sufficient width for one person, the water basin in this case should be made of earthenware, the whole width of the stall; the outlet should be in one corner, well trapped. The water supply should be automatic from a cistern placed above headway, it can be regulated to give a constant and regular flush; the service pipes should not be less than 1 inch to 1¼ inch diameter. The back of the stalls can also be made of slate; the flooring should be raised slightly above the ground or general floor line, and at the centre of the footway within the stalls it should be sunk, and a small trapped gully fixed to take off all water from the floor. The discharge from any single, or from a line of urinals, should be made *over* a trapped gully, and *disconnected from the drains*, or it may go into a receiver built in glazed brickwork, as described at p. 29. This receiver should be well ventilated.

Urinals for Hotels, &c.—These should be constructed of enamelled slate, both at the back and sides,

and fitted with china basins and patent solid drawn lead traps at the outlets; the water supply pipe should not be less than 1 inch diameter; the discharge should be automatic, and at fixed intervals. The footway is in most cases made of glazed earthenware with a gully at the centre to take off any surplus water. The division of the stalls need not be lower than the bottom of the basins, and the height 5 feet 9 inches above the footway, which should be about 4 inches above the floor of the room. Permanent ventilation should be provided in the outer wall of the room. The interior walls should be lined with glazed tiles, and the floor also covered with tiles.

Movable foot-boards, or treadles and levers, to operate the flush of water from a tank, are not to be recommended, as it is very difficult to keep them perfectly clean. The discharge from the basins, &c, should be carried by a 2-inch diameter pipe outside the building, and delivered over a trapped gully, disconnected from the drains, the gully should be made of earthenware; iron is not a suitable material in this case, it is soon corroded and is very difficult to keep clean and sweet; cast iron gullies, enamelled on the inside, have been used, but they are rather expensive, and do not always answer their purpose.

SINKS.

There are several kinds of sinks required in a public institution, for the kitchen and scullery, wards, dormitories, china room and pantries, and other

places. A leading type suitable for most places will be described; the size and details may have to be varied to suit special circumstances.

Scullery Sinks for Asylums, Unions, and Schools.—These may be made of slate slabs 1 inch thick, the size must be suitable to the particular case, an average in most large places will be 6 feet by 2 feet. The waste water must be taken away by a $2\frac{1}{2}$-inch diameter solid drawn lead pipe, 9 lb. per foot; the outlet grating and frame is of gun-metal, the grating being of large area, *it should be fixed in its place.* At the bottom of the sink, at the outlet, a solid drawn patent lead trap must be fitted, this must be provided with a cleaning cap and brass screw. The waste pipe must be carried through the wall outside the house or room, and delivered *over* a special trapped gully, as described in Chapter III. Hot and cold water, as well as rain water pipes and cocks, must be fixed at the sink, these should be 1 inch diameter; the cold service, lead pipe; the hot, wrought iron; the rain-water also wrought iron. The cocks should be solid bottom with packed glands, each fitted with a spanner securely pinned on to the top of the cone or plug of the cock. The cocks should be provided with a thread to screw into gun metal sockets or ferrules soldered to the T-pieces of the pipes; the cocks should not be soldered in the pipes anywhere, but be capable of easy removal for repairs. Draw-off cocks, for hot, cold, and rain water, should be provided at

the side of the sinks, or in some convenient position, and about 18 inches above the floor, for drawing water into pails, &c.; a trough lined with lead or made of earthenware should be placed under the cocks to take the drip; a waste pipe fitted up in the same manner as from the sink must be provided, and carried to the outside of the house and discharged over a grease receiver or gully well trapped.

A Draining Board of Slate, grooved at the top, should be placed at one side of the sink; this board must have a raised edge all round to retain the water. At the other side of the sink a washing basin should be provided for the servants to wash their hands; hot and cold and rain water should be laid on. The basin should be of the "tip" kind; the waste water taken away, and the fittings of the same kind as described for lavatories, the waste water from this basin goes into the waste water drains. In very large places a range of sinks may be necessary: they should not, however, be made too large, as it is difficult to keep them clean; the greatest attention is necessary to this important point, as the health of the inmates, at any rate of the servants, may be materially interfered with by unpleasant vapours, arising, not from the waste pipe, but from the dirty surface of the sink itself. Free ventilation directly over the sinks is a necessity. The sculleries must be perfectly ventilated, and supplied with inlets of fresh air as well as outlets for foul air, these latter ventilators should be made permanent and not under

the control of the servants, as otherwise it is almost impossible to ensure good and sufficient ventilation.

Sinks for the Wards, &c.—These must also be made of slate; they may be 3 feet 6 inches by 1 foot 7 inches, fitted with hot and cold, and, if possible, rain water service. The waste water is taken away and disposed of in the same manner as at the scullery, except that on the upper floors the discharge is made *over* a R.W.P. head; the discharge pipe may be 2 inches diameter, of lead 8 lb. per superficial foot. Hot and cold water cocks should be provided at the side of the sinks, and about 18 inches above the floor, to draw water when required; a sunk slate or glazed earthenware receiver should be placed under the cocks to take the drip, the waste must be taken away in the same manner as for the sink. Only small things are intended to be washed at these sinks.

Dormitory or Housemaids' Sinks.—These are also made of slate; they may be enamelled, and 1 inch thick; size about 3 feet by 1 foot 7 inches; the waste pipe 2 inches diameter, of solid drawn lead, 9 lb. per foot, with patent lead trap placed directly under the sink, and the waste water carried to the outside and discharged over a R.W.P. head as before described. Hot and cold water, and, if possible, rain water, should be laid on; the pipes and cocks $\frac{3}{4}$ inch diameter. Cocks for hot and cold water should be provided, to draw off at about 18 inches above the floor level, and a catch receiver of slate fitted, and

the waste discharged outside the building in the same manner as described for the last sink.

The two kinds of sinks above named should be placed in rooms divided from the wards, &c.; they should be well ventilated, care being taken that all the foul air is driven directly outside the house, and that it does not get into the wards and rooms. Great attention should be paid to this, otherwise much nuisance may arise, and effluvia, very detrimental to health, may find its way into the rooms occupied by the inmates.

Pantry Sink for Glass and Small China.—These sinks are for use in the infirmary, and in pantries for washing glass and other small things. They are made of hard wood, $1\frac{1}{4}$ inch thick, dovetailed at the corners, and lined with tinned copper sheeting $2\frac{1}{2}$ lb. per superficial foot; they should be made rounded, both at the corners and bottom, and should be turned over a rounded roll of hard wood at the top, and neatly nailed with tinned copper nails. The waste water must be taken away by a solid drawn lead pipe, $1\frac{1}{2}$ inch diameter and 9 lb. per foot. A patent trap, provided with a cleaning screw, must be fitted directly under the outlet of the sink; the gun-metal outlet is made sufficiently long to take the lead pipe; the end is provided with a half union, and to this the lead pipe is connected by a corresponding union. The waste is taken through the wall and discharged over a gully or R.W.P. head as before described. All

these wastes from washing water go into the No. 2 system of drain pipes hereafter described in Chapter III. The wall of the room at the back and under-part of the sinks should be lined with glazed tiles. These sinks need not be enclosed at the lower part unless so desired. Slate or earthenware sinks are not found to be suitable for glass and light china things, as there is much greater chance of breakage.

Sinks for Officers' Houses can be fitted up in the manner described in the author's book upon "Water Supply, Drainage, and Sanitary Appliances of Residences and Mansions." The nurses' and attendants' rooms in the infirmary may also be fitted in the same manner; they should be made of enamelled slate and of a superior description to those described for the wards and kitchens. Particular attention is directed to the careful trapping and the most suitable positions for these sinks.

The descriptions given for sinks are sufficient for all the separate types required; the number must depend upon the inmates and the method of working the place. Great care should be taken to make these useful appliances clean, sweet, and healthy; it is to be feared this is a department sadly neglected, and left too much in the hands of the plumber, whose ideas in many instances of the way of doing such work do not always accord with modern sanitary requirements This remark does not apply to several firms, who have made a speciality of this kind of

work, and always do it well. The architect must not always rely that the work will get into such experienced hands, especially when competition is so fierce, and the tenders of the cheapest firms are too often accepted by the client. By carefully specifying and describing all the work in detail, and as far as possible only permitting first-class firms to tender, a good job will be ensured, satisfactory not only to the architect, but to those who have the subsequent working of the place; added to this, *cheap* plumbing is sure to turn out *very dear* in the end.

LAVATORIES.

The lavatories for the officers' residences can be constructed in the same manner as those described in the author's book named at p. 1, to which the reader is referred for details.

Asylum and School Lavatories.—The lavatory basins should be of the "tip-up" kind made by G. Jennings; they are easily kept clean and can be lifted out readily to enable the under side and the top of the trap to be cleaned. The top is made of slate slab, and the skirting all round of the same material; the basins are usually set in ranges, the number depending upon the special requirements of the case. The slab should be supported on cast iron brackets; at the underside of the basins the waste water trough or receiver is placed; one or more outlet pipes are provided, depending upon the length of the lavatory

and the number of the basins. The waste water should be carried away by a lead waste pipe 9 lbs. per foot; a patent lead trap, provided with cleaning screw, should be fitted directly under each outlet; the waste pipes should be carried through the wall of the building, and delivered over a special trapped gully, and quite *disconnected* from the drain pipes.

Hot and cold water should be laid on, the pipes and cocks $\frac{3}{4}$-inch diameter; the best to use in asylums, &c., are solid bottom packed gland bib cocks fitted with spanners secured to the cones of the cocks by pins. The hot water cocks used in asylums are of a special kind, and are kept locked to prevent inmates scalding themselves. The walls of the room should either be covered with glazed tiles, or built with glazed bricks; the floor should be paved with tiles laid on concrete and set in cement.

Hotel Lavatories.—These are fitted up in much the same manner as the last described, except that the top slabs are usually marble, and the fittings of a superior character. The basins may be either of the tip kind or fitted with plugs and washers; the latter are in this instance preferable. The waste pipes should not be less than $1\frac{1}{2}$ inch diameter. A patent solid drawn lead trap, fitted with a cleaning screw, should be fitted directly under each basin. The waste water may be carried away by a pipe and discharged outside the building as before described.

Hot and cold water service should be provided;

the pipes $\frac{3}{4}$ inch diameter. The top slab should have recesses sunk for soap, but should not have any holes to take away the drainings, as they soon get stopped up, and are thus rendered useless for the purpose intended.

The walls of the rooms should be lined with glazed tiles and the floor laid with coloured tiles. The ventilation should have careful attention, both for the outlet of foul air as well as suitable inlets for the fresh air. Full details of the fittings of lavatory basins will be found in the book named on page 1.

BATHS FOR ASYLUMS, ETC.

The best kind to use are those made of fire-clay glazed inside. The most successful makers of these are Messrs. Rufford & Co., Stourbridge. They weigh about 6 cwt. Special provision must be made in the joists of the floor for carrying them. The outlets from the baths should have a patent lead trap, as described for lavatories, fitted immediately under them, and a solid drawn lead pipe 9 lb. per foot, 2 inches diameter, to carry away the waste water; it should be discharged either over a trapped gully if at the ground level, or over a rain water pipe head if the baths are placed on any of the upper floors. The cold service should be 1 inch diameter lead pipe; either a valve or cock may be used, the latter is generally preferred, worked either by a lever or spanner. The hot water pipe may be 1 inch

diameter, but of wrought iron. The cock should be made specially and kept locked, so that the bather cannot interfere with it and injure himself. The top of the baths may be woodwork, and also the enclosure at the sides, which should be made to open to examine the pipes. When the baths are placed on an upper floor, lead safings 6 lb. per superficial foot should be laid over the floor of the enclosures under the baths, a $1\frac{1}{2}$ inch diameter waste pipe, fitted with a copper flap valve at the end, is placed at one end of the safing to discharge outside the building as before described.

The dwarf walls or divisions of the rooms, where several baths are placed together, may be made with slate slabs, but single rooms should have the walls lined with glazed tiles or built with glazed bricks. The floors should be covered with tiles. Permanent ventilation should be provided in each room. The quantity of hot water allowed for one bath is 30 gallons at 150° F., and about 10 gallons of cold water. Neither the hot nor the cold water supply is under the control of the bather. The time allowed for bathing is $\frac{1}{4}$ hour, or three to four baths per hour.

A set of twelve baths would represent a large ward. The water is supplied from the hot water service main; this is treated under the head of "Water Supply." See Chapter IV.

Medical Baths.—Shower baths and other special kinds are supplied for the infirmaries of large places.

As these are of a more elaborate description, and vary very much according to requirements, further details will not be of much value, as they must be treated specially to suit the particular case.

Hotel Baths.—Baths for hotels do not much differ from those above described, except that they are fitted up in a better way, and the hot and cold water supply is left under the control of the bather. The baths are either made of wrought-iron glazed inside, copper plate tinned inside, or of fire clay. Cast iron, being liable to crack, is not a suitable material, and cannot be recommended. The enclosure of the bath is usually framed in mahogany 1 inch thick, and the top frame or capping $1\frac{1}{4}$ inch thick, and rounded on the edges. The bath rests upon a cradle of wood at a sufficient height to make the joints of the connecting pipes under it. The waste pipes should be 9 lb. lead, 2 inches diameter, and fitted with a patent solid drawn lead trap placed directly under the outlet from the bath, the hot and cold water pipes, 1 inch diameter, connected by a mixing chamber which is placed at the top of the bath framing. The size of the baths should be 5 feet 6 inches to 6 feet long, 2 feet wide, and 1 foot 10 inches deep; if made of copper, they should be 2 to $2\frac{1}{2}$ lb. per superficial foot, and tinned inside; if of wrought iron, No. 16 B.W.G., and glazed or enamelled inside. A lead safing must be provided under each bath, 6 lb. per superficial foot, with $1\frac{1}{2}$ inch diameter drain pipe carried outside the

building to take away any waste water. The safing must be turned up all round 3 inches deep, and nailed to the skirting. The discharge of waste water from the bath must be made over a rain water pipe head placed outside the building; the R.W.P., fitted with a shoe at the bottom, discharges over a trapped gully, and is entirely disconnected from all drain pipes. The walls of the room should be lined with glazed tiles, and a dado of different coloured tiles round the room, with a frieze at the top; the floor should be paved with coloured tiles set in cement. A bell-pull should be placed in a convenient position to the bather's hand, so that it can be easily reached. The bath room should be warmed by hot water pipes, and be well ventilated, both for the inlet of fresh air and outlet of vapour and foul air.

Swimming Baths.

These have often to be constructed for schools and other public institutions. The size will much depend upon the circumstances of the case. Taking a bath holding, say, 60,000 gallons, the highest level of the water being 18 inches from the coping or footway at the top of the bath, the extreme depth of the water should not exceed 5 feet 6 inches at one end; the other end may be 2 feet to 3 feet deep. The bottom should be constructed in concrete in Portland cement, the depth depending upon the nature of the soil, in any case not less than 1 foot 6 inches; it should be

paved with two courses of hard bricks set in cement, and one course of glazed fire bricks also set in cement. The walls should be built in brickwork, about two bricks thick, faced with glazed bricks, and set in cement; the walls may be backed with Portland cement concrete, say 12 inches thick; the thickness of the backing will depend upon the nature of the soil, as well as the local circumstances of the case. At the top of the bath a coping of York stone should be provided; this should be 4 inches thick and rounded on the edge. The bath should be heated by hot water circulating pipes 4 inches diameter; it requires about 350 to 400 feet run to raise the 60,000 gallons of water 15° to 20° in 7 to 7½ hours. Another plan is to let hot water flow in from a pipe in certain regulated quantities at the bottom at one end of the bath, and to flow out at the top at the other end.

Dressing-rooms should be placed round the bath. The roof should be well lighted and ventilated; the trusses should be wrought iron, close boarded, felted, and covered with slates; a lantern light fitted with swing windows and worked by simultaneous opening gear operated from the floor level, should be provided to give good ventilation. The walls of the room should be lined with glazed bricks, with a dado and strings of coloured bricks at intervals to take off the glare; the footway round the bath should be laid in coloured tiles set in Portland cement. The roof boards, rafters, and purlins should be wrought, and

all the woodwork painted in stone colour; the iron trusses painted blue, picked out with a maroon colour at prominent parts to relieve it. The decorating should be light and cheerful, and present an appearance of coolness. All parts of the building should be capable of being readily and economically cleansed.

The arrangements for changing the water must be regulated according to the number of bathers and the special circumstances of the case; the overflow from the bath takes place at the deep end; the valves may be arranged to keep a constant quantity flowing out at this end, while a fresh supply comes in at the other. The hot water would usually be supplied from the hot water service hereafter described.

In cases where the bath is placed some distance from the main building, a separate boiler may be provided; one 4 feet diameter by 10 feet long, with one 27-inch diameter tube is sufficient; it must be set in brickwork, and should be connected to a wrought-iron circulating tank, containing about 700 to 800 gallons. The circulating pipes are 4 inches diameter and are connected with this tank, and fitted as described under the head of warming apparatus. The heating of the water must always be carefully considered for each case, as the circumstances may considerably differ.

CHAPTER III.

DRAINAGE AND SEWAGE DISPOSAL.

Drainage.

All the drain pipes and sewers should be placed outside the buildings. Brick Barrel drains should never be used, nor should drain pipes of any kind be placed inside any building under the floors, except in the case of town houses, where special arrangements have to be made. This subject is specially treated in the author's book named on p. 1, to which the reader is referred.

Drain Pipes near the Building.—When the small extra expense is not an object, they should be of cast iron with socket joints, caulked with tarred yarn, and run with lead. All bends, junctions, and T-pieces should be of special make; each should be fitted with examination holes and covers, and sweeping connections provided with air tight covers; the pipes should be set to a regular fall of not less than 1 inch in 20 feet. All junctions should enter by Y-pipes and easy curves; the bends should be long sweeps, provided with cleaning caps, to allow tools to be passed through when required to remove any obstruction. Messrs. G. Waller and Co. make very

efficient tools for this purpose. T-piece junctions should be avoided where possible; if it is imperative to use them, the junction must be made by easy curves; sharp angles must always be avoided. The ground at the bottom of the trench should be well rammed; it is advisable to place Portland cement concrete about 6 inches to 9 inches thick under the line of the pipes. At intervals of 20 feet to 30 feet examination holes, fitted with air-tight covers and connections, should be provided; at these places a curved Y-pipe must be placed vertically, and be connected by a short length of straight pipe to an air-tight frame and cover placed at the ground level; the Y-pipe must be placed so as to permit the main pipe to be swept by the examination tools in the direction of the outfall of the sewer. The diameter of the main drain pipes may be 6 inches to 9 inches; this depends upon the quantity of sewage to be taken away. It is not a good plan to make the pipes too large, as they do not get well cleansed and flushed; many errors have been made in employing pipes of large diameter for this purpose.

For ordinary public institutions, say of 700 to 1000 inmates, the main sewer pipe receiving all the minor drain pipes need not be more than 12 inches diameter. The pipe connections from the closets should be from 6 inches diameter for single closets, and when several are in one group 8 inches diameter; the former size will, as a rule, be sufficient when not more than three closets are discharged at or near one spot.

The connections from the gullies of the sinks of the kitchens and sculleries should be 6 inches diameter. The connections for waste water from the gullies of the washing sinks should be 4 inches diameter; these discharge into a separate system of drains as hereafter described.

The rain water connections, 4-inch into 6-inch diameter pipes, discharge into their own system of drains, each R.W.P. is discharged *over* a gully trap which is connected directly with the main drain pipes, but the R.W.P. itself is absolutely cut off from any communication with the drains. The author is of opinion that the drain pipes from and near the house should *always be of cast iron.* They are as cheap in the end as stoneware pipes, and having few joints are less likely to leak, and are on that account the most advantageous to use. When well laid, and provided with proper examination and clearing holes as described, no repairs are required at any time, and much expense is saved in opening the ground and repairing and clearing, so often wanted in the case of stoneware pipes.

Earthenware Pipes.—After the soil drain pipes are away from the close vicinity of the house or building, they can be laid in best tested glazed stoneware pipes, the spigots must be well butted on a bed of cement to the bottom of the sockets, the joints made with Portland cement, and thoroughly filling the sockets. No cement or any part of the

jointing should be left in the interior of the pipe; it must be perfectly smooth and clear, and in a regular line; a ball, nearly the size of the pipes, should be attached to a cord and dragged through them as they are laid, to clear away any excrescence at the joints, and to ensure there is no obstruction in the interior. This matter does not always receive the attention it should have, hence some of the failures that occasionally take place. To ensure the perfect clearance and flushing of the drain pipes, they should be straight and clear on the inside, laid to even falls, and have no sharp corners or any irregularities to impede the flow of the sewage. Large sewer pipes, as before stated, are not desirable, as they are not so easily kept clean by flushing.

Soil Pipes.—These should be discharged into Receivers built of brickwork in Portland cement, the side walls being lined with glazed bricks, and the bottom laid with G. Jennings' patent vitrified earthenware, with open channels sunk in them. The size of these receivers must be made to suit the particular case; where not more than six closets are discharged at one spot, they may be 2 feet 3 inches by 2 feet 6 inches by 18 inches deep, covered with a York stone 4 inches thick, and fitted with a cast-iron frame and an air-tight cover, at least 18 inches in diameter. The chamber should not be made larger than absolutely necessary, as it is sometimes the means of collecting sewer gas, especially if not well ventilated.

The outlet from this chamber to the main drain is by means of a syphon pipe at one end, provided with a 6-inch diameter sweeping junction fitted with an air-tight cover. A ventilating cast-iron socket pipe jointed with lead 4 to 5 inches diameter, should be attached to the top of this chamber, and carried up to the top of the building, at least 4 feet above the eaves of the roof, clear of all windows. An air-inlet pipe of the same diameter must be attached to the other end of the chamber, fitted at the top with a "talc" *inlet* valve; this must be placed at a sufficient height clear of all windows, but need not be carried to the top of the building in all cases. It will be seen by this system the soil is discharged into a receiver *absolutely* cut off from the drain pipes, and supplied with fresh air and well ventilated, rendering it impossible for the entry of any sewer gas into the closets. It will be remembered the tops of the soil pipes are also ventilated by carrying them above the eaves of the roofs.

Urinal Wastes should be discharged into traps of glazed stoneware, or brickwork receivers, as described for the soil pipes, the latter would be used when there are several urinals placed together; when the waste pipe from the urinals has to run any distance, say beyond 8 to 9 feet, it should be provided with a ventilating pipe at the highest part of the pipe. The water is taken away into No. 1 Soil-pipe system.

Sink Outlets from Kitchens and Sculleries.—These should be discharged *over* a grease trap when the sinks are separate; the trap may be made in cast iron. The author employs a special design of his own, made with a receiver to lift out the grease, and means for cleaning all parts. The outlet from the trap is connected to the drains by a 6-inch syphon pipe. *The sink outlets are quite disconnected from the drains.* When several large sinks are discharged at one spot, a brick chamber, say 2 feet 6 inches by 2 feet 6 inches by 1 foot 6 inches deep, may be constructed in a similar manner to that described at p. 29. At the top an open grid with shrouded sides may be fixed. A grease-receiver is fitted to the chamber, to lift out periodically for cleansing. The waste water is run away through a syphon pipe at one corner; this is fitted with a sweeping junction, having an air-tight cover. This drainage goes to No. 1, or Soil system. It is very important to keep the fat and grease as much as possible out of the drains, as it causes much trouble, and helps to foul the sewage, as well as in some cases causing stoppages in the pipes by the grease solidifying and thus choking the passage.

Sink Outlets for Waste or Washing Water.—These should be discharged over cast-iron trapped gullies; and connected to the 6-inch main drains by 4-inch diameter pipes. The end of the waste pipe must be open to the air, and absolutely disconnected

from the sewer pipes. The author uses his own special gullies, which are provided with means for cleaning out. All the outlet water from washing sinks can be taken away in the same manner. Not more than two sinks need ever discharge into one gully; it is better to use separate ones, and connect the outlet from each by a 6-inch diameter main pipe. The waste water must run into a separate (No. 2) system of drains. The water is either discharged into "Soak-aways," or runs into separate tanks, to be treated as hereafter described.

Bath and Lavatory Waste Water.—This must be dealt with in the same manner as the last, and discharged into the No. 2 system of drains. The waste pipes, which, as before stated, should not be less at the outlet of the bath than 2-inch to 2½-inch diameter lead pipe, 9 lb. per foot, should deliver *over* trapped gullies of the same kind as at p. 19. When several baths discharge near the same spot, they may be taken into one main pipe of cast iron, close jointed, say 4 inches to 6 inches diameter, the end of this either discharging over a R.W.P. head which delivers over a trapped gully when the baths, &c., are placed on an upper floor, or direct over the gully when they are on the ground floor. The bath discharge pipe must be *absolutely disconnected* from the drains. When the length of this pipe is more than 8 feet to 9 feet, it should be fitted with a ventilating pipe, 4 inches diameter, rising from the highest part

of the pipe; this is to get rid of any foul air in it; soapy water is apt to get offensive. The outlet at the baths is provided, as will be remembered, with a patent solid drawn lead trap; they are thus completely cut off from the drains, and no sewer gas can rise into the bath-rooms. When there are a large number of baths, say about eight to ten, discharging at one point, special provision may have to be made for carrying away the waste water.

Rain-water from the Roofs of Buildings.—This should be discharged into a separate (No. 3) system of pipe drains, and carried away to storage tanks for use in sundry parts of the building or grounds. The construction of the tanks will be described under the head of Rain (see p. 53). The R.W.P. should have a shoe fitted at the bottom, and be made to discharge *over* cast-iron trapped gullies, described at p. 31. The pipes must be jointed at the sockets with iron cement; being open at the bottom a current of air passes up the pipes and so keeps them from fouling.

The special rain and waste water gullies, grease-traps, and cast-iron drain pipes and fittings, are made for the author by Messrs. George Waller & Co., London.

System of Drainage.—It will be seen from the above description there are three completely separate systems, viz.:—

No. 1. Soil pipe, Urinals, and Kitchen waste water.
,, 2. Baths, Lavatories, and washing water.
,, 3. Rain-water from the roofs of the buildings.

No. 1 is taken either to the town drains, if any exist, but more usually it will be necessary to discharge from the drains into sewage tanks, and afterwards to deodorise; this is treated at the end of the chapter.

No. 2 is taken either into "soak-away pits," or into separate tanks or receivers.

No. 3 into storage tanks for future use. These may be placed underground; their construction is described at p. 53.

All connection between the interior building and drains is *absolutely cut off and disconnected*; it thus renders the passage of sewer gas into any part of the house impossible. Any *direct* communication between the house and the drains *should never on any account be allowed.* Too great stress, even at the chance of repetition, cannot be laid upon this most important matter. The author advises architects at all times to rigidly adhere to this rule, and never to allow it to be broken on any pretence whatever.

The Soil Pipes, Receivers, &c., must be well ventilated, thoroughly trapped, and disconnected from any direct communication with the sewer pipes, and ample provision should be made to enable them to be examined, well flushed, and kept clean, as well as ready means for removing any obstruction.

By adopting the system of drainage here laid down the volume of sewage to be dealt with is much reduced, and a large saving in expense and trouble is effected. The bath and waste water from the lavatories and washing sinks, when mixed with the soil and kitchen drainage, very much increases the difficulty in dealing with it.

Main Sewer Pipe.—If this has to run any length, say above 100 feet, before the sewage falls into a tank or other receiver, it is advisable to provide a "disconnecting chamber" near the end of the buildings, and to cut off all communication with the rest of the sewer; this chamber should be 2 feet 6 inches by 2 feet 6 inches by 1 foot 6 inches deep, and must be provided with ventilating pipe, air inlet pipe, and fitted with iron frame and air-tight cover, in the same manner as described for the chamber named at p. 29.

The sewers may be flushed by a Field's patent automatic flushing cistern containing 150 to 200 gallons. This should be placed at the first part of the horizontal drains, and at the highest point; the apparatus can be arranged to discharge itself as often as may be required, and thus thoroughly cleanse the main pipes, and remove any obstruction that may have formed. No more water should be used than necessary, as it is not desirable to materially increase the volume of the sewage; as a rule a discharge twice per day will be sufficient to cleanse the main pipe. In any large system of sewers, in

addition to the ventilation pipes, &c., described for sundry places, one should be provided near the above flushing tank, as well as an air inlet; this keeps the pipes clear of sewer gas at the highest point of the system. There must be no dead ends in any part of the system of pipes and sewers, all must be laid to a regular fall, all junctions made with Y-pipes, and no square corners at any part permitted, especially at any inlet to the main pipe. The stoneware pipes should be obtained of the best makers, they should be specified as "*best tested pipes*," there is a great difference in the quality; a clause should be inserted also, "*that no part of the pipes or junctions* shall be covered in before they have been inspected and passed by the architect or engineer."

The pipes should be carefully laid by men specially skilled in this work. As before stated, each spigot end should butt against the bottom of the sockets, they should be laid in regular lines to ensure that the inside is quite smooth and free from any obstruction at the joints—the success of the whole system depends upon the care used. The fall of the pipes should be tested often by the clerk of works or foreman, to ensure that it is regular; he should also examine and test the interior to see that the joints have been properly made, and the inside of the pipes clear. A battering straight edge and level should be used on top of the pipes, holes being cut out where the sockets occur; this not only enables the level of the pipes to be tested, but shows if they are laid in

straight lines. In cases where the connections are made to any system of town drainage, they must be in accordance with their rules, and be inspected and passed by their surveyor; this course saves some trouble afterwards, as the responsibility will rest upon him, and not upon the architect or engineer, if everything is not quite satisfactory. It is advisable, if possible, that the architect should be present when the final junction to the town sewer is made, to ensure that the work is done in a proper manner, and that he may be able to give personal testimony to the efficient performance of this part of the work on any future occasion, should he be called upon to do so.

Stable, Cow-house, and other Drainage.—Drainage of this class must be put into a separate system of drains, and as a rule should be taken to a cesspool of sufficient capacity, and must be pumped out occasionally and spread over the land. The paving of the stalls should be sunk at the centre, and a trapped gully fitted with a dirt trap provided at this point; 4-inch diameter cast-iron socket pipes are laid under the paving of the stalls transversely, the gullies discharge into them. The back of the stall should be made rather higher than the front; it has been found by experience that animals, especially horses, prefer to stand with their hind legs higher than the front ones. The author is indebted to Mr. W. R. H. Sandeman, a leading London

brewer, for this suggestion. The floor of the stables, &c., should be laid in Stuart's patent granolithic concrete; it wears well, is easy to keep clean, and is preferable to blue paving bricks, which are very difficult to cleanse.

Sewage Disposal.

The sewage from the pipes and drains should be discharged into tanks, where it is treated; it is either thoroughly deodorised and the effluent run off into a convenient stream, or only partially deodorised and then pumped on to the land. The particular conditions of the case must settle this point, a decision as to which is to be adopted should be clearly understood before commencing the work, otherwise not only much extra cost may be incurred, but a risk of failure of the system.

The Tanks should be provided in duplicate, to allow for one set to be at work while the other is being cleared of the sludge and made ready for use again. The quantity of sewage to be disposed of every 24 hours must be ascertained; deducting the bath and lavatory water, this would not be more than 15 to 20 gallons per day for each inmate. Each set of tanks should hold two days' maximum discharge. The sewage should first be received in a chamber about 4 feet square, provided at the outlet to the next chamber with a wrought-iron strainer, also a wrought-iron perforated basket, nearly the size of

the chamber, to catch all solid matter; this basket is hung upon chains which are attached to an overhead gear and crab, and is raised to the surface periodically and cleaned out. The sewage water should then pass into the next chamber, first through a filter of coarse gravel, say 15 inches to 18 inches thick, and then through one of finer gravel or hoggin 9 inches to 12 inches thick. The filters may be formed thus: the sides may be of open iron work lined with perforated galvanised iron plates say $\frac{1}{4}$-inch thick, doors must be provided at the bottom to clean out and renew the filter as required; this process need not be done often, it depends upon the nature of the sewage to be treated. The sewage then passes into another chamber about 3 feet to 3 feet 6 inches wide into lime water, and dips under a slate slab, and falls over a weir into the settling tank. The sludge and thick part settles to the bottom, and the top is drawn off, by means of a floating pipe and valve, into a small chamber at the end. From the end chamber it is either pumped up, or when the level permits, it may fall into a brook or stream; the sewage at this point is completely innocuous and clear. When the pipe arrives near the thick deposit, the outlet valve is closed, and the duplicate tanks are set to work. The sludge is cleared out of the chamber, and put on the land, and when all has been properly cleansed, the set of chambers is ready to start again. The quantity of lime required is small, it need not exceed 10 grains per

1000 gallons of sewage. Care should be taken that only milk of lime is used, the mixture should never be super-saturated. Many other kinds of chemicals have been tried, but few are so satisfactory, simple, and cheap to apply, added to which, lime can always be readily obtained in all parts of the country. The lime water should be mixed in a separate apparatus, and run through fine sieves into the lime chamber as required.

Construction of Tanks.—The tanks may be made about 7 feet to 8 feet in depth, and of a width and length to hold the total quantity of sewage for forty-eight hours. The walls may be built in brickwork in cement 14 inches thick, and rendered with cement on the interior face; the bottom may be Portland cement concrete, about 12 inches thick, the floor being laid in cement or Stuart's granolithic paving. The top of the tanks can be arched over in brick-work in cement, or in cement concrete, on iron girders, with suitable manholes for cleaning out. There need be no smell or nuisance at the works if they are properly managed.

Where there is sufficient and suitable land to irrigate, the sewage is pumped up into upper covered tanks commanding all the levels, and then distributed by means of pipes and open conduits as required. In most soils it is advisable to under-drain the land by means of agricultural drain pipes; it has been proved at Wimbledon and other places to be very advantageous.

The solid matter is deodorised and put on the land as manure; in some cases it is mixed with fine ashes and other refuse—this, however, depends upon circumstances.

For very large places the sewage tanks must be on a more extensive scale; in some cases the inmates of these establishments are as many as a small town. Special arrangements must be made in such a case; it would be advisable to seek the advice of a consulting engineer skilled in such things, and let him lay out an efficient system, suitable to the special case.

It must be understood that the description given here of sewage disposal is of a simple character, suitable for ordinary cases when not of large extent; it would be impossible within the limits of this work to enter more in detail into this rather extensive subject.

CHAPTER IV.

WATER SUPPLY—COLD AND HOT SERVICE.

Cold Water Supply.

In most cases the water has to be obtained from a well sunk on the premises, the water being raised by pumps, either placed on the surface or down the well, according to the level of the water. The suction valves of the pumps must be within 25 feet of the lowest level the water is ever likely to fall to.

The most suitable pumps are three-throw lift pumps, worked by a crank; duplicate sets should always be provided. The pumps are fixed in the well on girders placed at a suitable depth; the crank shaft is at the top of the well, and runs in bearings resting upon girders framed together; connecting rods of the requisite length are taken to the pumps, and a suitable number of guides and girders should be provided. One suction and one rising main are required. The size of the pumps will depend upon the quantity of water to be raised per hour.

The water should be raised by the well pumps into a lower tank, and by other pumps fixed on the floor of the engine house into a tank placed in a water tower, either in part of the building or as a

separate construction. This tank should command all the other supply tanks. The details of the pumps and engines, &c., are given in Chapter IX. The water should be distributed from the main tank by a system of pipes, the diameter of which will depend upon the quantity required. A pipe 7 inches diameter will supply a large establishment of say 1000 inmates.

Two separate and independent supplies should be provided, one for drinking, washing, baths, and cooking, and an entirely separate service for the water-closets.

Water Tanks, constructed of cast iron, should be fixed on top of different parts of the building, under the roof in all cases, and supplied by the main tank in the water tower. These tanks should not exceed 4 feet to 4 feet 6 inches in depth. The flanged joints should be planed, and put together with red lead, and secured by bolts and nuts; these should be about 4 inches, centre to centre. They should be supported at each line of the joints on the bottom by wrought-iron girders, on which they must take an even bearing, and be set perfectly level. The interior of the tanks may be lined with glazed bricks set in cement; this of course adds much to their weight, but where the walls are strong, and as it does not materially increase the cost of the girders, it is advisable to do it. The water supply main to the house should be taken from the bottom of the tank; the pipe should rise about 3 inches above the

bottom, and have a perforated rose over it. A circular cover or dash plate, say about 18 inches to 24 inches diameter, standing upon legs about 9 inches above the bottom of tank, should be provided, the legs being bolted to the bottom plates, which thus saves an eddy current, that would otherwise draw in air and make a noise in the mains. In one corner of the tank the plate should be sunk, and in this should be fitted a gun-metal washer and hollow plug having a copper-plate trumpet pipe attached; the top of this is placed about 3 inches below the top of the tank. The waste pipe under this outlet must be the same diameter as the inlet pipe. A Baxter's patent machine can be attached a little below the tank to give warning of any waste. The hollow overflow pipe is removed whenever the tank has to be washed out. As a precaution a valve may be provided directly under the tank to shut off in case of emergency should the waste pipe by any accident become displaced. The tanks should be provided with a wood cover formed of two layers of boards, each $1\frac{1}{4}$ inches thick, with felt between them, and a manhole and door hung upon hinges at one side to permit of examination and cleaning out.

Pipes.—The diameter of the main down pipe need not exceed 6 inches; branches can be taken from it to supply each floor as needed. The supply to the baths and lavatories may be from 2 inches to 3 inches diameter, according to the number. For the closets

2 inches diameter, and $1\frac{1}{4}$ inch for each of the sinks. Valves should be placed in the mains, to shut off any section if required. The pipes should either be hung on the walls, or run in channels sunk in them or in the floor; they must never be sunk or built in the walls or plaster, and the cold and hot service should always be placed in separate channels. Cocks must be provided in suitable positions for draining the different sections of the mains when cleaning out the tanks, &c. The staircases are suitable places to fix the pipes, a supply being taken off at each floor.

Feed Cisterns to various apparatus (excepting the water-closets) are taken off the mains, and are fitted with ball valves and overflow pipes. In some instances, where the pressure from the main tanks might be inconvenient, smaller tanks of wrought iron are placed near the spot where the water is wanted, and at a level sufficient to command the places to be supplied.

Water Closet Service Tanks, &c.—Tanks quite separate from the house supply should be provided and fixed at the top of the building. The sizes of these will depend upon the number of closets to be supplied; they may either be made of cast iron or wrought iron; if the latter, $\frac{3}{16}$ inch thick, they may be placed on timber, if no wrought-iron girders are available; a tank of about 200 to 250 gallons will afford a good supply of water to, say six closets.

In cases where the closets are placed at each end of a block or set of wards, it may be convenient to have a separate supply tank for each set. The down main may be cast iron 3 inches diameter, with $1\frac{1}{2}$ inch wrought iron service to each closet. The tanks must be fitted with overflow pipe, ball valve, &c., the same as the large tank. The rising main that supplies the house tanks may supply those for the water closets, but no connection of any kind must be made to the water closet down supply pipe for any other purpose. The service of pipes must be kept *absolutely distinct.*

Tanks of all kinds should be cleaned out periodically, not less than six times per year. Notices to this effect should be posted in the tank room. All tanks should be provided with close covers, fitted with man-holes and hinged flaps for examination; in all cases they should be placed *under* the roof, and in a place that can be kept clean and well ventilated; they should never be near any water closet, sink, or where any vapour or effluvia is likely to arise. The rising mains can be taken inside the building up the staircases; if in any very exposed or open passages, they should be felted and enclosed in wood boxes to protect them from the severe weather. No connections of any kind should be taken off the rising main, except for the supply of any low-level tank.

Fittings.—The cocks should be solid bottom

packed, either bib or straight-through cocks, according to the purpose. The cones should have spanners fitted to them and fastened on. Where cocks are placed in a line of pipes, they should be connected by unions, to permit of easy removal for repairs, &c. The service pipes, where exposed to the weather, must be protected by felt and cased in wood boxes.

Fire Mains.—This service should be taken direct from the water tower or principal tank. The main may be 6 inches diameter, divided into 4 and 3-inch pipes at the corridors and staircases; the T outlets should be flanged and 2½ inches diameter. The pipes must be so placed that a hose can be readily connected, to enable the attendant to perfectly command every necessary part. The cocks for the hose should be attached to the T-pieces and have screwed ends and unions with the same thread as used by the Metropolitan Fire Brigade. Hose pipes and nozzles should be hung near each cock; everything should be kept ready and in perfect working order for immediate use.

Buckets of water should also be provided at each floor or corridor; they should be hung just clear of the headway, and should be emptied and filled *once per week.* By this means the water is not only kept clean, but the buckets are sure to be charged when wanted. The author has in several instances known of fires being put out, and serious damage saved by

their being immediately used as soon as the fire was discovered.

The constant supervision of all cocks, hose, nozzles, &c., is a very important thing, also to draw up a proper set of clear short rules, telling attendants what to do in cases of emergency, which should be posted in conspicuous places, where they can be easily read, and especially at each fire cock and union. Once every two or three weeks the hose should be taken down and examined, and water run through it to ensure that it is in working order. It is advisable to have periodical fire drills of the attendants, to ensure that every man knows his post and what he is to do, in case of fire. Every operation should be done in a fixed number of minutes, duly laid down in the rules. The time for turning out the engines and setting to work must also be laid down and duly kept. This plan ensures general smartness in case of need.

For clearing the wards and rooms quickly in case of fire, it is necessary to provide iron staircases fixed outside the building, with a platform at each floor, and doors communicating with same. The stairs should be at least 3 feet 3 inches wide, not too steep, say 6 inch risers and 7 inch treads of open ironwork, the hand rails 3 feet 8 inches high.

Water Supply for Out-buildings.—This can be by a separate set of tanks supplied direct from the pumps after the large tanks are charged; the number,

contents, and position of these will depend upon their particular use; the fittings will be the same as for the house tanks. Cast-iron tanks are the most suitable; they can be placed on the top of any building or in a water tower of sufficient height to command each place where water is required. They must be covered over with double boards felted between; a man-hole must be left in one corner of each for cleaning out; all pipes exposed to the open air must be protected. Fire mains may be connected with these tanks, and hose, &c., provided for the purpose of extinguishing fires in the outbuildings, stables, cowhouses, &c.

Hot Water Supply.

The water is heated in a boiler and passes to wrought-iron circulating tanks, with "flow" and "return" pipes. The flow pipe is taken from the top of the tank and carried on a constant rise to the several floors and rooms, &c. The hot water is drawn off the flow pipe, and at the highest point it is provided with an expansion pipe to give relief when necessary.

All the hot water required for the baths, lavatories and sinks, &c., is taken off this service. The circulating tanks require cleaning out at least four times per year, as much deposit is usually formed in them. A boiler, set in brickwork of a size suitable for the work to be done, is placed in the basement of the building; the size depends upon the number of baths

and lavatory basins to be supplied, also the number of sinks and the amount of hot water wanted for cleaning and other purposes. The circulating or hot water tank should hold at least one hour's supply. The temperature of the water should be about 170°; in lunatic asylums it is, however, seldom made more than 150°. The "flow" and "return" pipes should be 3 inches diameter, the services to the baths and lavatories 2 inches diameter, reduced to $1\frac{1}{4}$ inch at the baths and 1 inch at the lavatories. All the water is taken from the "flow" pipe; a perfect circulation must be maintained. The boiler is fed with cold water from one of the upper tanks, either in direct communication with it or from a feed tank placed above the top of the flow pipe; the water entering the feed tank is regulated by a ball valve.

This apparatus is entirely separate from the warming apparatus for the rooms. The pipes must be provided with expansion joints, and rest on rollers hung in cast-iron carriages. They must not be fixed at any part, but left free to move as they expand and contract.

The above apparatus will also supply hot water at the sinks and washing places, also at any of the rooms where hot water is wanted. When the blocks of the buildings are not placed far apart, one boiler may serve one or more blocks, the size being proportioned to the quantity of hot water required per hour. The boiler must be in duplicate for use when cleaning out or any repairs are necessary.

The Hot Water Pipes should be covered with Le Roy's patent non-conducting composition; they must be conveyed in separate channels from the cold water pipes, both in the floors and walls. Expansion joints must be provided, and the pipes must not be built in the wall at any part. Valves should also be provided to shut off any section, aud also under the cold water supply tank. The pipes, &c., must be arranged so that the whole system can be emptied when it is necessary to clean out. At suitable points, 1 inch diameter bib cocks should be provided to draw off water where required; a small lead sink should be placed under the cocks, fitted with waste-water pipe and trap, and discharged into the waste water system of drains.

In very large establishments the boilers are usually grouped together in sections at suitable points. It is not advisable, however, to place them far from the part where the hot water is wanted, or some difficulty may be experienced in maintaining a good circulation.

Softening Water.

When the water obtained from a well is hard, and contains lime, it is advisable to use one of the patent processes for accomplishing this purpose. The Atkins' Filter Company's process is one of the most satisfactory; it is stated the cost of softening does not exceed 1*d.* per 1000 gallons. It is a

great advantage to have soft water for boilers and heating apparatus, and if it can be obtained for the small price named it should be used. Experience has shown that the boilers and pipes, &c., last a much longer time clean, and the former do not wear out so quickly when fed with soft water. There appears no need to dilate upon the many advantages gained by the use of softened water for domestic purposes. Many of the provincial water companies are now softening all their water, to the very great advantage of the consumers. For laundry work, where rain water cannot be obtained, a great saving is effected in the items of soap and soda alone. In cooking upon a large scale, it is a great advantage to have soft water, especially for meat and vegetables; the latter are better cooked, and also have a better flavour. In making tea and coffee upon a large scale, a very considerable saving is effected; it has been stated by an eminent chef that one-third of the tea, &c., is saved as against that made with hard water.

The use of soft water in the apparatus for supplying hot water for washing is also of very great advantage, not only as far as the interior of the apparatus is concerned, but in washing-water for baths and lavatories; much soap is saved, and it is easier to wash clean.

Rain Water Collection and Supply.

The rain water from the roofs should be collected from the gullies before named, and run through drain pipes into underground tanks. These may be constructed in concrete as detailed below. Allow for contents for fall of rain about an average of 3 to 3½ inches per month. Take the area of the buildings in square feet and allow about 3 inches deep, this will give the contents of the tank for one month's rainfall; it is, however, advisable where possible to provide sufficient capacity for storage of two months' fall. At the end of the discharge of the R.W. drain pipe into the tank, a small filter box should be provided to keep back the dirt and grit. The filtering material may be fine gravel and sand; the sides of the filter should be made of fine copper wire mesh.

A Tank to hold 60,000 *gallons* would be 64 feet by 25 feet, by 6 feet deep. The side walls should be 24 inches thick from the bottom half-way up to 18 inches thick at top, of Portland cement concrete, the bottom 18 inches thick; all the interior should be rendered in cement. The top should be arched over in concrete 12 inches thick, springing from girders 12 inches by 6 inches by ⅝ inch. A division wall 18 inches to 20 inches thick, should run down the centre, with openings in it to form one tank. A manhole should be provided, with a cast iron frame and cover 30 inches by 26 inches, and foot irons to the bottom of the tank should be fixed

in the side wall. An overflow pipe 4 inches diameter should be provided; a "sumpt" hole or recess should be formed in the bottom of tank for the dirt to fall into when emptied to be cleaned out. The water should be raised to the supply tanks by a separate set of pumps, and delivered into upper cast- or wrought-iron tanks at a sufficient level to command the place where the water is required. As it will principally be used for kitchen, washing, and laundry purposes, the tanks need not be placed more than 10 feet above the ground line.

Pipes for Rain Water.—These may be wrought iron 2 inches diameter for mains, and 1¼ inch for service pipes; as they are mostly for washing and cleaning purposes, they are not usually carried above the ground floor.

The storage of rain water does not receive the attention it deserves: it is not only very convenient for use, but saves much pumping when water has to be obtained from a deep well. The approximate cost of a concrete tank, described at p. 53, is about 450*l.*; it of course depends upon the locality and the nature of the soil in which it is constructed. As a rough rule the cost may be taken at about 15*s.* to 16*s.* per 100 gallons, when the depth does not exceed 6 feet. Smaller tanks will cost more. The above cost is only given to enable the designer to determine if he is able to go to the expense named; it will always pay to construct these tanks, and store the water.

It may be convenient to catch some of the water at the kitchen or laundry departments in small tanks at a height to command the sinks; they may be constructed of wrought iron $\frac{3}{16}$ inch thick, and may contain about 250 to 300 gallons; they must be provided with overflow pipes, and also be connected to the delivery main from the rain water pumps, to obtain water from the store tanks should the local supply fail.

CHAPTER V.

WARMING APPARATUS.

The warming of large buildings is a matter requiring much consideration as to the best system to be adopted. There are three principal plans, "hot water," "steam," and "hot air"; the former may be divided into two systems, high and low pressure; the advantages of each of these will be discussed, and a general description given to enable the architect to form an opinion which is the best to adopt for his particular case. The matter should be carefully studied in all its bearings, and a system should be decided on before the building is commenced, in order to make suitable provision for the pipes, boilers, and other apparatus. Heating by hot water, either on the high or low pressure systems, is generally used for the buildings under discussion. Steam heating is only suitable for workshops, laundries, or warehouses. The hot air system is not much adopted; it is, however, occasionally used for churches, chapels, and large meeting rooms. It is not so economical in the use of fuel as the hot water apparatus; the first cost of fixing is rather less, but the subsequent repairs to the heating stoves is more than in the other systems.

High-Pressure Hot Water System.—There are many advantages in using this system in large places, especially in churches, chapels, schools, &c.; the pipes are small in diameter, can be conveniently passed through walls and floors, and can be stowed away in small spaces; the cutting away, when applied to old buildings, is much less than in other systems. The simplicity of working also commends itself; it wants no skilled attention, and is perfectly safe. The heat in the pipes and coils is got up rapidly, and can be maintained with a small amount of fuel. The hot water pipes are $\frac{7}{8}$ inch bore and $1\frac{5}{16}$ inch diameter outside; a coil of the same diameter is placed within a furnace; a pipe rises from the top of this coil to the highest point to be heated, and then returns to the *bottom* of the coil in the furnace; the pipes and coil are completely closed; from their small diameter, they contain very little water, and so are rapidly heated, and the heat easily maintained. An expansion pipe or chamber, containing about one-twelfth of the whole contents of the coil and circulating pipes, is provided at the *highest* point of the pipes. This pipe is also closed. Near this a cock is fitted to the horizontal pipe, to fill the coil only, the expansion pipe being left quite empty. As the water in the pipe coil in the furnace gets heated it becomes lighter, and ascends from the *top* of the coil into the "flow" pipes, and the water in the other pipe descends to the *bottom* of the coil. All the coils for heating the rooms are taken off the

"flow" pipe; the joints of the pipes are made by sockets screwed with right and left hand threads, the end of one pipe being made with a flat face, and the one to which it is jointed with a V-shape face; the joint is made by metallic contact between the faces only, by screwing up the right and left hand sockets. The size of the furnace and the length of coil in it depends upon the capacity of the rooms, &c., to be heated.

Coil Cases are used for some of the rooms; in other instances the hot pipes are run round the rooms or wards, and are hung on the skirtings, but are *not* sunk into the floor. The length of pipe required for each 54 cubic feet of space is about 12 inches to 18 inches for heating to a temperature of 60° to 65°. The furnace requires very little attention; the heat is got up rapidly in the pipes, and all is under perfect control. After the pipes are once started in good working order, there is no trouble with leakage of the joints at any future time; the whole apparatus lasts for many years. The wear is very small; it gives less trouble than any other system, both in working and as to any subsequent repairs and renewals.

The cost of the apparatus is more than the "low-pressure" system; there are, however, many cases where this would not be prohibitory. The author considers the system of Messrs. Perkins & Sons, London, the most efficient. This firm has carried out works for him most successfully.

Low-pressure System Hot Water Pipes.—This system is perhaps more used for asylums, unions, and schools than the high pressure above described.

The manner of heating the water is much the same as that described at p. 49 for hot water supply, except that the coils and pipes are endless, and form in the present case a perfect circulation; on this depends the whole success of the apparatus. Great care must be used to ensure this; it is not so easy a thing to effect as may appear to many. The water is heated in a boiler set in brickwork, from the *top* of which a "flow" pipe 4 inches diameter rises to the highest point required; off this pipe connections are made at the various floors, &c., where heating has to be done; and at the highest point of the horizontal pipe a "return" pipe falls to the *bottom* of the boiler. At the top of the "flow" pipe an expansion or relief pipe is carried up through the roof; this pipe need not be more than 2 inches diameter; it is for the purpose of giving relief to the pipes as the water expands, and to prevent any undue pressure in the boiler or pipes in any part of the system. The waste of water is small; it is made up from a cold water feed tank as required; the supply to this tank is taken from one of the large supply tanks, and is regulated by a ball valve.

The heating of the rooms may be done in two ways; either the pipes may be taken around them at the skirting, or coil boxes and cases may be fixed on the floor; the pipes in these boxes are not usually

more than 3 inches diameter. Air valves are fitted to each coil box, to take off the air at the highest points. The corridors may be heated in the same manner. The pipes should never be sunk in channels in these parts. Radiators may be used instead of coil boxes, the effect is much the same; they, however, give rather more heat than coil boxes, but in many cases, as in lunatic asylums, they could not be used in some of the wards, &c., unless covered over. Air cocks must be provided in the lines of pipes, especially at the bends; the perfect circulation of water in the pipes depends upon all the air being excluded. No dips must be made in the pipes; each horizontal "flow" pipe should have a constant rise, and all "return" pipes a regular fall, to the boiler. The pipes must be laid and jointed with the greatest care; they must be perfectly flush inside, no excrescence of any kind must be left in the interior.

The cubical contents of the room must be calculated, allowances being made for windows, the quantity of 4-inch diameter pipe required will be 12 feet run per 1000 cubic feet of space for a heat of 55°, and for 65° say 14 feet run. There may be special cases where more may be necessary; as a rule, the quantity named is sufficient. In systems where 3-inch pipes are used, add one-third to the above quantity; and for 2-inch pipe coils allow double the length of the 4-inch. Attention must be paid to any place where a rush of cold air may take place, extra pipe should be allowed at these points.

The boiler must be proportioned to the number of feet of pipe; the best kind to use is the same as that named at p. 49; they are made in the same manner as a steam boiler, but as they are worked full of water, the brickwork setting is carried up nearly to the top of the shell. A safety valve should be provided at the boiler to give relief if the pressure from any cause increases beyond the proper amount.

Valves are supplied to shut off any section of the pipes; they must be arranged so as not to interfere with the circulation of water in the pipes. The pipes are socket jointed, made with gasket soaked in red and white lead, with a small portion of red lead to finish at the top. This joint answers the best, as it is semi-elastic; it allows the pipes, when they expand and do not get relief elsewhere, to move in the sockets, added to which, a pipe can be more easily cut out when alterations are necessary, without breaking the end of the pipe or the socket to which it is attached. The pipes should rest upon rollers hung on cast-iron carriages and left free to move; they must not be held at any part, and in no place must they be built in the walls. At certain places expansion joints must be provided. Great care must be taken with the levels of the horizontal pipes, also as to their true jointing; each of the lengths must be in a perfect line with the rest, and the interior must be smooth at the joints and clear of red lead and other jointing. It is a good plan to drag a wooden ball attached to a cord through the pipes to

ensure that the way is quite clear, and to rub away any dirt or jointing materials, and also to test the absence of any obstruction left in by accident.

The object to be attained is to procure a perfect circulation of water; the success of the whole apparatus, as before stated, depends upon this. All sharp bends and junctions of any kind should be avoided. No water must be drawn from the pipes for any other purpose. The "flow" pipe, where it is not wanted for heating any room, &c., may be covered with non-conducting composition. Means must be supplied to drain the boiler and the whole system of pipes when not required for use, and in places where the water forms much deposit, a certain quantity should be run off as occasion requires. Under the head of Water Supply, at p. 52, the advantages of using water that has been softened in heating apparatus is mentioned.

Pipes sunk in trenches should be avoided when possible, partly because they become receptacles for dirt and dust, and also on account of the extra expense of the trenches and gratings, added to which, draughts are often created at the floor level. For churches, school rooms, and meeting rooms, the author prefers to use coil boxes or "radiators;" they warm more quickly, and avoid the smells that are sometimes emitted from the trenches, either caused by damp air or dirt and dust falling into them; it is almost next to impossible to keep them clean. Very full details are given in the author's

book named, at p. 1, of the fitting up of warming apparatus, especially for smaller places; the reader is referred to it for all minor details.

Quality of Pipes.—The pipes used should only be obtained from the best manufacturers, as there is a great difference in quality. Competition, unfortunately, in this as in other things, tempts firms to offer indifferent goods, and in many cases they succeed in inducing the user to take them. The best quality are made by the old-established firm of Messrs. Bailey, Pegg, & Co., London, who have also carried out for the author a large amount of warming apparatus work in a most efficient and satisfactory manner.

Steam Heating.—There may be some cases where rooms and corridors may be isolated from the hot water pipes, but near a steam boiler, where this plan may with advantage be adopted; as a general rule it cannot be so much recommended as either the high or low pressure hot water system. The pipes are much more liable to leakage, and the expansion and contraction in them is also much more. The pipes in this case may be 3 or 4 inches diameter, flanged and bolted together; the joints should be faced and made with red lead. Expansion pipes, capable of freely moving, should be provided; and no pipes must be built into the walls anywhere. This rule must be rigidly observed, or trouble will follow. The heating of the rooms is done by coil cases or

"radiators," as before; the condense water is taken away at the lowest part of them by a pipe 1 inch diameter to proper condense boxes placed in suitable position; they are so arranged that condensed water is discharged, but no steam. Air cocks are provided at the coils and at sundry places in the pipes to eject the air. Dead ends in the supply pipes should be avoided wherever possible; it is not, however, necessary to return the pipe to the boiler in the same manner as for the hot water system. The level of the pipes must be carefully looked to, that they drain themselves of all condensed water by gravitation to the condense boxes.

The quantity of 4-inch pipes required is about the same as for hot water (low pressure), remembering that where 3-inch diameter are used instead of 4-inch, one-third must be added, and when 2-inch diameter, double the quantity required for 4-inch. There are many cases where 2-inch pipes for rooms are more convenient than the larger sizes. At each of the connections, at the different floors, &c., also at each coil box, or "radiator," cocks are provided to shut off. The 2-inch pipes should be wrought iron, all the others may be cast iron. A pressure above 10 lb. per square inch must be used; if a high pressure is on the boiler which supplies the steam to the pipes and coils, a reducing valve should be fitted at the commencement of the pipes, to lower the steam to a pressure not to exceed 20 lb. to 25 lb. per square inch. Any pressure above this is not

economical to use. Greenhaugh's patent valves accomplish this very well, are simple, and not expensive.

Hot Air Apparatus.—This system is not so suitable as either of the others described for asylums, infirmaries, schools, &c. It is more costly to work, and there is a certain element of danger from fire; the flues and air ducts are liable to become over-heated. The air of the room is also not so agreeable or healthy to breathe, being sometimes charged with heated particles of dust and dirt. For churches and public rooms it may sometimes be adopted with advantage; but as a general rule, where the hot water system can be used it is to be preferred. Mr. J. Grundy appears to have been successful in getting rid of many of the objections to the system, in addition to which he applies the hot air system in combination with hot water pipes; he claims for this a great advantage, and states that he successfully gets rid of all the objections complained of. The heat of large rooms, especially churches, can be got up much more rapidly; and the draughts which are sometimes created by the low pressure hot water apparatus are avoided. The fuel required for the furnaces, as well as the labour in attending to them, is much more than that for either of the hot water systems.

Smaller rooms, where an open fire is desired, can be heated and ventilated by "Grundy's Patent

Warm Air Grates." The stove is constructed with a chamber at the back of the fire for heating the fresh cold air, which is taken in from the outside of the house at this point; the back of the fire grate has "gills" or projecting pieces cast on. The smoke from the fire is taken up an iron flue to the chimney; all round the flue a warm air chamber is constructed, the outlet of which is into the room through a "hit and miss" ventilator; this chamber is closely sealed from the smoke shaft and chimney above. These stoves are very suitable for sick wards, where a constant stream of warm and fresh air is most desirable, as well as the cheerful appearance of an open fire. All rooms are more easily ventilated in which an open fire is burning; many people, especially invalids, do not think they are warm unless they can see a fire.

Ventilation of the Rooms, &c.—It must be remembered that no system of heating can be successful unless the rooms are well ventilated, both as regards the discharge of the heated and foul air, and the admission of fresh air. Wards and corridors, &c., should have top ventilation, either by a lantern in the roof, when no rooms are placed over them, or by ventilators in the outer walls; the inlet of cold air can be made with Tobin's patent ventilators, say at 5 feet from the floor line. All corridors and passages should be freely ventilated in the same manner. The staircases and landings

should be ventilated by a top skylight or air-shaft, free inlets of fresh air being provided at suitable places. Some of the exhaust ventilators placed in the roof, especially in the case of large rooms, are very successful, and are to be recommended. In large rooms, such as meeting or school rooms, &c., the air should be frequently changed without making a draught; top ventilation is the most essential in this case. Where the room or place has a double roof, cold air can be admitted at one end and ejected at the other. Outlets or valves should be provided in the inner roof; these should be shielded at the top and side from the current of cold air; by this means a slight vacuum is formed, and down draught prevented. In some instances it is necessary to introduce a stream of cold air near the under part of the ceiling or lower roof, to create a current; this may either be done by inlet valves with pipes turned up towards the roof, or by opening a section of the top windows near the roof and forming a rectangular box with lid or valve at the top of it; the lower part of the glass of the window is left out. The cold air in this case enters and goes straight up to the roof, and does not fall down into the room and create discomfort to the inmates.

CHAPTER VI.

LIFTING MACHINERY.

THIS subject, as applied to mansions and houses, has been fully treated in the author's book named, at p. 1; many of the apparatus therein detailed are also suitable for small public institutions, and schools, &c. It is proposed in the present book to treat of machines applicable to large institutions only, such as lunatic asylums, unions, infirmaries, hospitals, public schools, hotels, residential blocks of buildings, &c. Some of the machines described can be used for many of these places, others are more useful in the particular cases cited. It would be impossible to describe machinery suitable to each case in detail; an endeavour will be made to give a good general idea, leaving it to the architect to select types most suitable for his purpose. In all cases the saving of labour and trouble afforded by these machines is an essential consideration, to which must be added the great facility they give for carrying on the business of large places satisfactorily. As far as possible, the best type of lifts to adopt for different places will be indicated, but no detailed description will be given when they do not much differ in the details from

like kinds of lifts already described for another description of institution.

Lifts for Lunatic Asylums.—As a rule, in large places of this kind, the dining halls and other meeting rooms are placed on the ground floor; where this is the case, "food lifts" are not necessary, the kitchens being usually placed also upon the ground floor. Small food lifts may be useful to carry up food to the infirm wards; this, however, only applies in some cases, because in many asylums the aged and infirm are placed on the ground floor. Lifts are also useful for taking coal to the upper floors; various types worked by hand and hydraulic power, will now be described, and full details given to enable the architect to specify what he requires. The circumstances of the case will enable him to decide the way of working and the best form adapted for his purpose.

Hand-power Lifts.—In some places hydraulic power may not be available; in this case hand lifts must be used; they are described in detail in the book named, at p. 1. The cages, guide irons, and counterbalance weights are the same as in the hydraulic power lifts. The lifting rope is of hemp, and is attached to the top of the cage, and then passes over a spocket or grooved wheel fixed at the top of the lift hole. The rope is gripped in the groove; the other end is attached to the counterbalance weight, sliding in a channel on L iron guides, as

hereafter described. The shaft on which the spocket wheel is keyed has also a spur toothed wheel attached; this gears into a spur pinion keyed on an upper shaft, and on this shaft a large grooved wheel is keyed, on which an endless rope works. The rope passes by means of cast iron eyelets through each floor to a lower grooved wheel sunk under the bottom floor or basement; this is hung upon an adjustable pin, and so keeps the working hand-rope tight. Clutch gear is provided to throw the wheels in and out of work, and rods are attached and carried to the bottom of the lift, so as to control the movement at any floor. On the first motion shaft a brake wheel is keyed, fitted with strap and lever; a rope is attached to the end of this lever, and carried through each floor outside the lift hole to the cage. It will thus be seen that the cage can be operated from any floor.

Lifts of the same kind may be used for raising invalids, when hydraulic power cannot be obtained. The author does not, however, recommend their use when it can be avoided. Safety apparatus must be provided at the top of the cage, to prevent accidents in case of the rope breaking. All the details of enclosures, shutters, &c., apply in the same way as for the hydraulic lifts.

Inclined Lifts for Cellars.—For raising and lowering coal, beer, oil-casks, and other goods, lifts are sometimes made upon the following plan. Two inclined wrought iron trough girders, or timbers with

rails fixed on them, are bolted to the floor of the cellar and also to the sill of the loop hole at the flaps at the ground level; on these rails a table or carriage travels, running on four wheels. A chain is attached to the front of the platform, and passes over a leading grooved pulley fixed at the top of the inclined girders, and then down to a crab motion fixed in the cellar; a brake wheel, brake, and lever are provided, by means of which all loads can be lowered by gravity. There are many modifications that have been designed and used by the author, that are described in detail in his book upon 'Hydraulic, Steam, and Hand-power Lifting Machinery,' to which the designer is referred; nearly every case likely to arise has been well considered and provided for.

Hand-power Food Lifts for Hotels.—These must be specially constructed, according to the requirements of the place. The number will depend upon the system on which the hotel is worked; it is a very good plan to provide a lift for each floor, capable of landing only at the particular floor required; this is for the purpose of ensuring that the things are delivered to the floor where they have been ordered. Much trouble is saved by this, both in time and in the proper and prompt execution of orders. Mr. E. A. Gruning, F.R.I.B.A., was the originator of this system, to whom the author is indebted for the idea. The lifts may be constructed in the same way as

those described at p. 69, and may range from boxes of 1 foot 6 inches by 1 foot 6 inches by 2 feet, to 4 feet by 3 feet by 4 feet 6 inehes high. The boxes are usually provided with shelves, and with raeks in some eases to earry glasses and tumblers, &e.

Hydraulic Coal Lifts.—In large plaees these should be worked by hydraulic power, by the fall of water from the tank in the water tower deseribed at p. 42. A raek and piston, or cylinder and movable pulleys are the best to be adopted to work the eages in whieh the load is eontained. As the raek and piston lifts are more generally used for this purpose, they will be the first deseribed. The diameter of the eylinder and the length of the stroke will depend upon the load to be raised, and the height, also the pressure of water available. Take the height of the tank above the cylinder of the lift in feet, and divide by $2 \cdot 3$ = pressure of the water in lbs. per square ineh. Deeide the ratio of the stroke of the eylinder to the total height to be raised; thus, suppose it to be 60 feet, it would be convenient to make the proportion of the stroke as 1 to 10, that is, the stroke of the lifting cylinder would be 6 feet. The pressure on the under side of the piston must therefore be ten times the amount that would be required to raise the load direet; to this must be added 25 per cent. for friction, the unbalaneed weight of eage, and a slight margin over. The eylinder is made with an open top; a

toothed rack is bolted on the top side of the piston; this works into a pinion geared to another motion, on which shaft is keyed the winding drum, this is proportioned to take the full length of the lifting rope or chain. The water is let into the cylinder at the bottom under the piston and discharged from the same place. The cage is framed in L and T-irons, and made in the form of a box open in the front only; to the top of this box a steel wire rope or chain is attached; this passes up to the top of the lift hole over a grooved pulley, and down to a corresponding pulley fixed in the basement under the cage, and then over the drum wheel, on which it is wound. The cage is guided by T-irons $2\frac{1}{2}$ inches by $2\frac{1}{2}$ inches by $\frac{1}{2}$ inch; these are fixed to the interior framing or walls of the lift hole. Part of the weight of the cage, say two-thirds, is taken by a cast iron counterbalance weight, grooves are planed in the sides, it works between two 2-inch by 2-inch by $\frac{3}{8}$-inch L-iron guides, fixed in a channel in the back wall of the lift hole. A wire rope is also attached to the bottom of the cage, and passes under a lower wheel, and then on to the winding drum on the reverse side to the lifting rope; this is for the purpose of keeping the rope taut and in its place. This system was introduced by the author about 18 years since; it has been most satisfactory in working, and no accident by the rope coming off the wheel has ever occurred since its adoption. The lift is controlled by a valve box and gear rod, the

latter passes up the whole height of the lift hole. Automatic gear should be provided to shut off the water pressure at the *top* and *bottom* of the lift hole. Spring buffers must also be provided at the bottom to take the blow of the cage, in case of the gear not acting from any cause. The speed of these lifts need not exceed 100 to 120 feet per minute.

Hydraulic Cylinders with Movable Pulleys.— This class of lifting power is sometimes adopted; the cylinder in this case is closed at the top as well as at the bottom, the ram or piston rod passes through a stuffing box at one end, and at the top of it movable pulleys are attached, and at the bottom of the cylinder like kind of pulleys are provided. The lifting chain (in this case) is attached at the end of the cylinder, and then passes over the movable and fixed pulleys to the wheel placed over the cage at the top of the well hole. The friction in this kind of lifting cylinder, is rather more than the last described, and should have a margin of 30 to 35 per cent. allowed for friction, instead of 25 per cent. as in the other kind.

The cage, guides, counterbalance, valves, and working rods are the same as in the other case. The lift holes must be enclosed in brickwork, the openings at each floor should be made 3 feet above it, and provided with a shelf to land the scuttles, &c., on. Shutters, hung like a window sash, must also be provided at the openings, and must be fitted with

spring locks. No one should be allowed on any pretence to ride in the cages; this, as a rule, is provided against by making them not more than 4 feet high.

Self-acting Hydraulic Ram Lifts.—For cellars and stores these are the most suitable, and are operated by the fall of water from the tank before named. The lift consists of a cast iron cylinder sunk in the ground, in which a ram works; it is kept tight by a leather collar at the top of the cylinder. On the top of the ram a platform of wrought iron is fixed, and on this the goods are lifted. The ram and platform are guided by 3-inch by 3-inch by ½-inch T irons running the whole height of the lift. A counterbalance is attached by chains to the platform; it has grooves planed in the sides, and runs in L iron guides, which are fixed to the back wall or at the sides of the lift hole, as convenience may require. A valve box worked by rods which run the whole height of the lift is provided, and by means of this gear the raising and lowering is controlled. To calculate the size of the ram, find the pressure per square inch of the water from the tank, as noted at p. 72; take the number of lbs. to be raised, divide by the pressure per square inch = area required for the ram in square inches. For friction add 10 per cent. in this case; the actual amount of friction in well made lifts is much less than this. The platform is

made of wrought iron, properly stayed underneath, and is provided with guide plates, which work upon the before named T iron guides. The ram is cast iron, and made hollow, and about $\frac{1}{2}$ inch to $\frac{5}{8}$ inch thick. The cylinder is flanged at the top and bottom; the top part is bored out, and a leather collar is fitted in a recess, this forms the packing, and is much superior to a gland packing, and causes less friction. These lifts are absolutely safe and easily controlled, are self-acting, and can be made of any stroke required. There are many purposes to which they can be applied in an asylum, such as raising or lowering beer, wine, or oil casks, coal trucks from the stores when placed underground, or for raising food from the kitchen to an upper floor; this work, however, should not be done by this kind of lift when the stroke exceeds 10 feet, on account of the expense of boring the well.

The size of the inlet pipes in all classes of hydraulic lifts is proportioned to the pressure or head of water; increasing the size of the inlet pipe does not affect the *power* in any way, only the *speed* of the lift, this matter should have careful attention and should not, as a rule, be left to the manufacturer.

Lifts for Unions and Infirmaries.

Coal and Food Lifts may be constructed in the same forms as above described, both for hand and hydraulic power. For raising aged and infirm

people, who are in many cases placed on some of the upper floors, one or more passenger lifts may be advisable. The only absolutely safe apparatus are those worked by hydraulic power on the continuous ram and direct acting principle—a type of which will now be described.

Passenger Hydraulic Lifts.—A well is sunk in the ground equal to the height the lift is to be raised; in this a cast-iron flanged cylinder is sunk, made in lengths and bolted together. A hollow ram works in the cylinder, through a bored top part, in the same manner as the short stroke lifts described at p. 75. On the top of this ram the cage or ascending room is fixed. The ram is made in sections of about 9 feet long, and screwed together. The attachment to the cage is made by a bolt passing through a boss fixed to the wrought iron framing of the cage; safety bolts are also provided, which would take the strain should the large bolt break. All these bolts are made of steel. The cage is constructed in L and T iron framing, lined with woodwork; a wood floor is bolted to the lower frame of the cage; at each of the sides at top and bottom rubbing guides are provided.

Guide bars, of cast iron, V shape, planed on the faces, are fixed to the walls of the lift holes. Chains are attached at each side of the cage to projecting arms, and these work up and down in grooves or channels in the side walls; the chain passes over grooved wheels placed on the top of each side wall,

and then to the counterbalance weights; these have grooves planed in them on each side, and work between L iron guides fixed in recesses in each of the side walls. A valve box and gear rod is provided; the latter runs the whole height of the lift hole, thus allowing the lift to be controlled at any floor; the rod in this case passes inside the lift, to prevent anyone interfering with it.

Automatic gear is provided to shut off the pressure of water at the highest and lowest points. An air-vessel fitted with a cock is provided on the top of the inlet and outlet pipe; this prevents any shock to those in the cage if suddenly stopped.

The lift hole must be enclosed in brickwork, and doors provided at each floor to open from the inside *only*. A guard rope must also be provided at each floor to prevent any accident, should the doors from any carelessness be left open.

When machines of this kind have to be adopted, the architect is recommended to seek the advice of a consulting engineer experienced in this class of work, and not to put himself without reserve into the hands of rival manufacturers, some of whom do not perform the work in a satisfactory way. When the work is all duly specified, and only competent firms invited to tender, a good and reliable apparatus will be obtained. Nearly all the accidents that have occurred with lifts have been the result of improper design and bad workmanship. The author ventures to give the above advice, knowing by experience how

essential it is to have good lifts, and how very risky it is to take them only because a low offer has been made.

Hospital Lifts.

Coal and food lifts should be the same as described in p. 72. The size of the cage will depend upon the number of rooms to be served and the quantity to be taken up; for coals the maximum weight need not exceed 10 cwt., and for food say 3 to 4 cwt. These lifts should be separate for each block of the building. The coal lifts can also be used for bringing down ashes and other refuse from the wards. The food lifts should only be used for their own purpose and for taking up medicine and medical appliances. The cages of the coal lifts should be made without shelves; the food lift cages should be made with them. The details of construction of this class of lift are the same as described at p. 72. All the lifts in a hospital must be enclosed in brickwork, with doors for the passenger lifts and shutters for the food and other lifts at each floor. All openings must be kept locked when not in use, and only those who are specially appointed should be permitted to use them.

Lifts for patients should be made in the same way as the passenger lifts for Unions, &c., last described (at p. 77), except that the cage must not be less than 7 feet 6 inches deep, the width 5 feet 6 inches, and

the height 6 feet 6 inches, all inside dimensions. The patients should be raised in chairs or sofas, set on springs and running on wheels, all of which are made to swivel. They can be run out of the wards on to the floor of the cage of the lift, raised up to any of the upper floors, and wheeled away as desired. The author has put up a large number of lifts of this kind at hospitals and infirmaries. They are the only lifts that should be used for patients in hospitals, especially for accident cases. The motion is so smooth and noiseless, no extra suffering is felt by the patient; added to this, their absolute safety should decide their use for such purposes.

These lifts are also used for mortuary purposes; the coffins or shells are placed on a truck fitted with swivel wheels; they are run into the cage, and in most instances are lowered to the basement out of sight, and raised again by another lift at the mortuary, which is usually situated near the medical school attached to the hospital. Anyone dying in the wards is moved almost without the knowledge of the other patients, and after the coffin enters the cage of the lift, it is not seen by any one passing along any of the passages; much pain to the other patients is thus saved.

Mortuary Lifts.—These are constructed in the same manner as described at p. 75, of the direct-acting ram kind. A platform about 7 feet long by 3 feet 6 inches wide is bolted to the top of the ram.

On this the truck on wheels carrying the coffin is placed. Self-acting stopping gear is provided at the highest and lowest points; all the other parts of the lift are constructed as before described.

These lifts may also be made upon the short cylinder system, described at p. 72. The platform in this case is suspended by "wire" rope or chains, the stroke of the cylinder being made about 2 to 1 when the height to be raised is not more than 10 feet to 12 feet. The mortuary chamber is, as a rule, placed on the ground floor.

Hotel Lifts.

For hotels three or four classes of lifts should be provided—"passenger," "luggage," "coal and ashes," and "food," the number of each depending on the general disposition of the lower rooms and passages with regard to the upper floors, and the relative position where the passengers or coal, &c., have to be landed.

Passenger Lifts.—The number of these must depend upon the size and arrangement of the hotel; as a rule, unless it is a very large establishment, only one is provided, placed at or near the staircase. The lifts should always be constructed on the continuous ram system, the same as described for "Unions" and "Hospitals" (see pp. 77–79). In cases in London and other large towns, where power can be obtained from the "Hydraulic Power Company's" mains, the ram

is made of steel tubes, screwed together in about 9 to 10 feet lengths. The author does not advise a less diameter than 6 inches, especially in high lifts, as there is a risk of the ram bending. In lifts of this kind no counterbalance weight is usually required, on account of the high pressure (about 700 lb. per square inch) on the mains; this is a great advantage in some respects, and saves cost in construction; but for lifts above 30 feet to 40 feet, the author prefers to use a counterbalance to take part of the weight of the cage and ram, because the thrust on the ram is thus saved, and part of the load is in suspension. The interior of the cages may be lighted by gas lamps by means of a flexible tube, which rises and falls with the cage at the outside. The author introduced this system about eleven years ago; it answers the purpose admirably.

It may here be stated *that lifts on the "continuous ram system" are the only really absolutely safe ones to use for passengers.* All cages suspended from chains can never be made *perfectly* safe. The author strongly advises architects never to use this latter type of construction for lifting passengers.

Luggage Lifts.—When the attendants have to travel with the luggage, these lifts should be made on the same system as the passenger lifts. It is not a bad plan in this case, and one that the author has several times adopted, to place the luggage lift next to the passenger; this affords a lift for use when any repairs are necessary to the other lift. The settles

and seats are made portable; these have to be shifted and a carpet laid down, and the lift is ready for use. This plan saves much trouble and also inconvenience to the guests of the hotel, as means of raising them to the various floors is always available.

When the luggage has only to be taken up say two or three floors, and the attendant *is not required to travel in the lift*, it may be constructed in the same way as coal lifts, described at pp. 72–76.

Coal Lifts need not differ from those at p. 72; the number and position of these must depend upon the disposition of the rooms in the hotel; their power, and the sizes and strengths of the cages, lifting ropes, and other parts, will much depend upon the work to be done, the size of the hotel, and other circumstances. All the ashes and rubbish should be taken down in close metal boxes in these lifts; these may be placed on wheels and run direct into the cage of the lift.

Kitchen and Food Lifts.—For raising the joints, &c., to the carving and serving room, the lifts may be worked by hydraulic power. They are usually made with double cages; as the cage rises on one side it opens the shutter, which closes by its own gravity as the cage descends. These lifts are also used for raising the plates and other table appliances, except in cases where it may be necessary to have a lift communicating with the plate and dish pantry

or room. In most large places this plan is adopted; a great saving of time is effected when serving large dinners. The rest of the food and other things can be raised by the hand-power lifts described at p. 69.

The means of moving and raising food and table things is a matter requiring the close attention of architects; on the careful consideration of all these matters the economical and efficient working of this department of the hotel will depend. Unfortunately, it often happens these things do not get the attention they deserve. The author thinks he may have given sufficient information and hints to lead to more careful treatment of all such things.

Residential Blocks of Buildings.—These large establishments are now becoming so general, and are carried to such a great height, it becomes imperative to provide lifting machinery to raise and lower passengers and goods. For passengers the same kind of lifts are required as described for hotels. The luggage may be raised in the passenger lifts. Coal and food lifts may also be of the same kind as for hotels. The number of each class of lift required must be settled according to the especial wants of the place; in blocks of any length at least two passenger lifts will be necessary. An attendant should work each; tenants should not be permitted to touch or work them on any account. All classes of lifts in places of this kind should be enclosed in brickwork, and be provided with a door at each floor;

those for passengers should be capable of opening *only* from the inside of the lift hole. An indicator should be supplied to show at any floor the position of the lift. Electric bell signals should be fitted, to give notice to the attendant on which floor the lift is wanted by any person wishing to use it. The system to work the lifts, and the consequent details of construction, must depend upon whether the water pressure from the "Hydraulic Power Company's" mains is available. Whenever it is possible to obtain the power, it is always advisable to use it.

Lifts for Public Schools.—The lifts required here do not much differ from those at hotels, except that none for passengers are wanted. The food lifts may in this case only be required for the upper floors, to serve invalids and their attendants.

The kitchen in most of the schools is generally situated on the same floor as the dining hall, but in public schools in London and other large towns they may be placed on the basement floor. Any other class of things can be raised by the lifts described for asylums and hospitals. The general arrangements and manner of working schools do not much differ from asylums as far as the food, coal, and other matters are concerned, and as no special lifts are required, further details need not be given.

Lifts.—These machines, worked either by Hand or by Hydraulic power, may be required for many other

establishments not specially named, but as the work to be performed does not materially differ from those already described, and as the fullest details are also given in the author's book named at p. 1, for Residences and Mansions, he believes every place of importance has been covered. He would here again venture to caution architects to adopt only the best designs, and to see that only first class firms are allowed to do this work; this course of action will save both himself and clients much trouble in the future working of the place. The great competition that exists in this class of work has been most detrimental to the efficiency of the machines, and also to the carrying out of the work in a sound and satisfactory manner. Possibly few appliances in large places have received so little attention from architects as lifts, although they are such essential apparatus for properly and successfully carrying on the business of the public institutions herein named.

Steam Lifts and others of Special Types.—These lifts, principally suitable for factories, mills, and places of like kind, have not been described, as they do not come within the scope of this book; full details will, however, be found in the author's work named, at p. 87, and also for special purposes in his books on 'Breweries and Maltings,' and in 'Gas Works Construction,' all published by E. & F. N. Spon, London. For the public institutions under consideration, steam lifts are seldom suitable; there

are only a few isolated instances where it would be advisable to adopt them.

The application of lifting machinery is of so wide a character, it is impossible to enter into further detail without extending the book far beyond the limits assigned to it, and perhaps giving more elaborate detail than most architects require. In most other cases, it would be desirable to place the work in the hands of a skilled consulting engineer.

Any one requiring any further details of hand or hydraulic power lifts suitable for special positions and purposes, is referred to the author's book upon 'Hydraulic, Hand-power, and Steam Lifting Machinery:' E. & F. N. Spon, London. In this will be found close details of most forms of machines suitable for nearly every case likely to arise.

CHAPTER VII.

KITCHEN AND COOKING APPARATUS AND BAKERY.

Apparatus of this kind for mansions, &c., has been described in the book mentioned, at p. 1, some of which would be suitable for small public institutions, say of 300 people. In the first instance a few suggestions as to the best way to construct kitchens to contain the apparatus may be of some service.

The rooms should be constructed with open roofs, with a lantern on the top for light and ventilation; the roof trusses should be wrought iron, with wood purlins and rafters, and close boarded and slated; the height from the floor line to the wall plate should not be less than 14 feet to 15 feet; the walls should be lined on the inside with glazed bricks, the floor laid in Portland cement concrete, and covered with red and black tiles. The swing sashes in the lantern should be operated by simultaneous opening gear from the floor of the room. The apparatus hereafter described should be ranged all round the walls of the room, wrought iron hoods should be provided over all the apparatus, with wrought iron shafts passing through the roof as required, to take away the vapour and steam. At the top of each of these shafts a hood should be provided to prevent any

down draught into the kitchen. At each apparatus where a draw-off cock is necessary, a small copper tray or trough should be provided with an iron trapped gully, discharging into a cast-iron pipe drain under the floor; examination holes and air tight covers of gun metal must be provided at intervals for cleaning and removal of stoppages.

The gas and steam ovens may be placed near each other, the steam boiling pans together. The carving and serving table at an opening in the wall convenient to the main passage to and from the kitchen. The frying, broiling, and boiling gas stoves may be placed in the centre of the room, the larger boiling and frying stoves may be situated next the walls under the iron hoods if there is sufficient space.

Gas Ovens.—For large institutions of say 1000 to 1500 people, the construction should be as follows. The size inside may be 6 feet by 3 feet 6 inches by 4 feet 2 inches high, the sides and top may be of wrought iron ¼-inch thick, no bottom is required, the casing is fitted with a cast-iron front plate, and two cast-iron doors; the hinges, latches, and catches, should be wrought iron; the box is put together with L-iron, and riveted, and in front an L-iron ring runs round, to which the cast-iron front is bolted; loose trays and grids of wrought iron are fitted to the inside, supported on L-iron slides at heights to suit the various foods to be cooked. The inside of the oven, as well as the doors, should be

lined with glazed white tiles set in Portland cement. A ventilating pipe, say 4 inches diameter, must be attached to the top of the oven; "hit and miss" ventilators should also be provided in each door. The gas burners should be placed all round the oven at the bottom, the size of the pipe should be 1 inch diameter, and the rings round the oven $\frac{3}{4}$ inch diameter, the burners $1\frac{1}{2}$ inches apart. In many instances it is convenient to divide the oven into two compartments by a partition of $\frac{1}{4}$ inch plate iron, lined on each side with tiles. This oven will cook 570 lbs. of meat in about $2\frac{1}{2}$ hours, at an average cost of gas, taking it at 2*s*. 6*d*. per thousand, of about 8*d*.

In institutions of say about 500 people, an oven 2 feet 6 inches by 2 feet 6 inches by 4 feet high will be sufficient; it should be fitted up in the same manner as the last.

Gas Boiling Tables.—A table made of cast iron, 6 feet by 4 feet, is bolted to four cast-iron columns or legs, standing 3 feet high from the floor line to the top of the table. In the top plate oval and circular holes are formed, to suit various sized pots and vessels. Wrought-iron tripods may stand over the holes. The gas pipes are carried under the table and connected to perforated rings placed in the oval and round holes; cocks are provided at each hole to regulate the gas. This table may also be used for stewing, and making food for invalids. The gas

consumed on the average is about 120 cubic feet per hour.

Gas Frying and Broiling Tables.—The size of the table may be the same as the last; the holes and gas burners must be made to suit the cooking pans, &c. On this table may be cooked soles and other fish, chops and steaks, and any like kind of food requiring either broiling or frying. On a table of this kind 70 soles may be fried in two hours, and other things cooked, at an expense for gas of about 5*d.* to 6*d.* This apparatus may be made in different forms to suit various kinds of work.

Gas Broiling Stove.—For cooking chops and steaks, or bacon, &c., a stove made of cast iron, 1 foot 8 inches by 1 foot 6 inches by 6 inches deep, may be provided; it should have a gas pipe ring all round, and may stand upon any convenient table. Twelve chops may be cooked by this at one time; or six chops may be cooked under the stove by reflected heat, and small things boiled on the top at the same time. This is also a very useful little apparatus for cooking many small things that need not be detailed. The amount of gas consumed is very small.

Steam Oven.—For cooking potatoes this apparatus should be made of cast iron, about $\frac{9}{16}$ inch thick, in one piece, rounded at the corners, and with a flange running all round at the front, to which is bolted a cast-iron front plate, fitted with two doors,

&c., as described for the gas oven. The casting for this oven forms a box, so that when the doors, which are made steam-tight, are closed, the interior is sealed, except a small ventilating pipe and valve at the top which is provided to carry away vapour. On the sides of the box L iron slides are provided, on which perforated zinc trays rest; these contain the potatoes. A steam pipe and cock 1 inch diameter is fitted at the bottom of the oven; hit and miss ventilators are also fitted to the doors. The bottom of the oven is provided with a sunk channel to receive the condense water. The size of the oven inside should be 6 feet by 3 feet 6 inches by 4 feet 2 inches high. About 20 bushels of potatoes can be cooked in two hours. The exhaust steam from any adjacent steam engine is sufficient for heating the oven, and answers the purpose equally well as live steam from a boiler.

Steam Jacketed Boiling Vessels.—For making soup, boiling meat, puddings, or vegetables, vessels of this kind are used. Meat and vegetables may sometimes be boiled together; a separate pan should be used for soup, and another for puddings. The large pans are made rectangular, with rounded corners; the outer jacket is a cast-iron box, with rounded corners, open at the top. A flange is cast all round the top; to this an internal vessel made of copper plate 12 lb. per foot, is bolted by countersunk bolts. The joint is made thus: the cast-iron flange

is faced, and on this the flange of the internal vessel rests; a plate of cast iron is placed on top of the copper, and the whole is then bolted together by gun-metal cup-headed bolts. A cover of copper, dome shape, 7 lb. per superficial foot, is provided; this is hinged at the back to the top plate, and is fitted with a chain and counterbalance weight. The copper cover is riveted to a flat face of gun-metal, which rests when closed upon a planed face on the top cover. The vessel is by this means made steam-tight. At the back of the jacket a vent pipe is fitted, which discharges the steam and vapour under the iron hoods placed over the apparatus.

A steam pipe with cock $1\frac{1}{4}$ inch diameter is fitted to the jacket for the admission of steam, and a condense pipe is also fitted to the bottom; the condense water runs away to a condense box. A draw-off cock 2 inches diameter is fitted to the internal vessel; the pipe passes through the external one to the outside. The size of the copper vessel inside should be 5 feet by 2 feet 6 inches by 2 feet 6 inches deep; it will hold 195 gallons of liquid.

Tea Coppers.—These may be made 3 feet diameter by 1 foot 9 inches deep inside the copper vessel which may be made of 10 lb. copper. The jacket should be cast iron, $\frac{9}{16}$ inch thick, and hemispherical in shape; the steam pipe 1 inch diameter. The cover and fittings and the other details may be constructed in the same manner as the last. The

pan will hold 56 gallons. The draw-off cock $1\frac{1}{2}$ inch diameter passes through from the interior vessel to the outside of the jacket.

Broth, &c., in small quantities may be made in a pan the same as the above as to the construction, but the inside pan, made 2 feet diameter by 1 foot 6 inches deep; it will hold 26 gallons; steam pipe $\frac{3}{4}$ inch diameter. It may have a cover in the same way as the other, or may be left open. The outer jacket may rest on cast-iron columns, and stand 3 feet from the floor line to top of the pan.

Steam Carving and Serving Table.—A table made of cast iron, about 20 feet by 3 feet wide, and standing about 3 feet from the floor line, must be provided and placed next the wall, and at the part indicated at p. 89. This plate must have sunk jacketed pans or dishes to receive the meat, &c.; the top plate is cast iron; it should be planed and polished; the sunk vessels should have receptacles of copper, and the outer shell cast iron, leaving chambers into which steam is introduced by $\frac{1}{2}$-inch diameter pipes and cocks. The number of hot vessels or recesses will depend upon the number of dishes to be served at a meal; taking an average for 1500 people, it would not be less than eight to ten; the length of the table in this case would be about 20 feet.

In a few cases the serving table is placed in the dining hall or in an adjoining room or lobby, the

special circumstances of the case will determine this. In any case a hot table, heated by steam, to place the joints upon when dished up, is of great advantage, and should always be provided when the serving table is placed out of the kitchen.

Open Range.—One of these should be provided in the kitchen to roast meat, poultry, and other things; it should have two ovens attached; most of the baking on a large scale would be done at one of the ovens in the bakery. Some of the cooking for the chief resident officers is done at this range.

Vegetable Kitchen.—A separate room should be provided for preparing vegetables. A machine for washing potatoes may be placed in a shed close to the room, and in the room or the shed a small machine for washing vegetables should also be provided; both of these may be worked by hand power. A sink or trough of slate should be fixed against the wall near the window to wash salads, &c. The capacity of all these apparatus will depend upon the size of the place and the diet; in nearly all cases the vegetables to be prepared are a large matter, and proper arrangements should be made for dealing with them in an expeditious manner.

Scullery.—This room should be away from the kitchen, and, if possible, detached from it. The walls should be lined with glazed bricks, and the floor

covered with tiles; a lantern roof, the same as the kitchen, should be provided. Ample ventilation should be given, and means of regulating; at the same time a fixed amount of opening that cannot be altered, both for the inlet and outlet of air, should always be given, otherwise there is a chance of the room having no ventilation if left to the servants; the sink and other fittings are described in Chapter II.

Several modifications of all the above apparatus may be made, both as to size and details of arrangement. Assuming that the apparatus herein detailed would be sufficient for say 1500 inmates and above, about half the size of each vessel or apparatus would do for 750 people; in all cases it is better to have enough and to spare, and in many instances it is more convenient, while supplying the same capacity in the apparatus, to cut up the contents into more vessels, so as to have facilities for cooking smaller quantities if required; the first cost of the apparatus is somewhat more, but the expense of working it is no more when the vessels are divided. The dimensions of the kitchen will of course depend upon the size of each of the apparatus and the number it is required to place round the room.

This is a department where help from a consulting engineer, specially skilled in this apparatus, should be sought, as it requires great care in planning, as also the room in which it is contained. The author wishes here to acknowledge that he is indebted to Mr. Henry Martin, C.E., the engineer and surveyor

to the Middlesex and other county asylums, for particulars of many of the apparatus herein described, which he, in conjunction with the gentleman named, has carried out at various places. In this department, as well as in others, it is impossible to do more than indicate the best kind of apparatus, each particular case will have to be dealt with according to its requirements. All the vessels, &c., described are the result of actual working experience. The author hopes he will be pardoned for advising the architect to well consider what is required for his case, and also to specify the dimensions and description of apparatus, and not leave it to individual manufacturers, who are interested too often in supplying the cheapest but not the best things.

BAKERY.

This most important department is usually situated near the kitchen. It should be divided into two sections: one room for mixing and making the bread, with a room over it for a flour store; and one room for the bake-house; it should be built in a similar manner to the kitchen, with an open roof and glazed lantern at the top. The walls of each room should be lined with glazed bricks, and the floor covered with tiles on concrete and set in Portland cement. Good light and ventilation are a necessity, as well as every proper arrangement that will induce cleanliness. In the first room all the bread making is done; the troughs for mixing may

be placed next the wall at the windows, and the kneading machines in the middle of the room. The ovens are placed in the second room, with their back ends to the wall, leaving a sufficient space in front to draw the bread.

Troughs may either be made of wood or slate; in each case they are fixed in their place, and are provided with an outlet plug for washing out. Hot and cold water should be laid on at each trough, and also at convenient places in the room where washing down is necessary.

Kneading Machines.—Those made by Messrs. Stevens & Co. are the most suitable; they are driven by steam power, and are simple in construction and easily kept clean. A small engine may be placed in the same room as the machine, or shafting may be supplied, driven by any adjacent engine, and thence by strap-gear to the machines.

Wood Hoppers to contain the flour for daily use should be fixed above the mixing troughs, and should be fitted with an outlet valve, worked by levers and rods from the floor of the room. The sacks of flour are stored on the upper floor, and are tipped as required into the hoppers or bins. The sacks should be pulled up by sack-tackle barrel gear and driven by the shafting before named, or a small hydraulic lift may be used, either of the ram or the short cylinder type, similar to those described at p. 74, 75.

Ovens.—These may be made on three different plans, and either be heated by fire, gas, or hot water. The fire ovens are not so much used now as formerly. The hot-water ovens by Messrs. Perkins and Sons are much approved of and very economical in working. A full description of these will be found in the author's book named, at p. 7. The baking ovens are placed in a separate room, as before described. The number of the ovens will, of course, depend upon the size of the place and the requirements; in any case two ovens should always be provided, so as to have one for use in case of repairs being requisite.

Ovens heated by gas are made by Mr. W. J. Booer, Southwark; they have been very successful in operation, as well as economical as to cost of working. Fire ovens may be altered into gas ovens at a small expense. A 10-bushel oven can be heated by gas in 1¾ hours, with a consumption of 450 cubic feet of gas; time of baking bread, 2 hours. To re-heat the oven for the next batch 270 cubic feet of gas are used; time in the oven, 2 hours, as before. The quantity of coal required to heat a 10-bushel oven is about 1 cwt., and the subsequent heatings take about one-half that quantity. The saving in cost effected is not much, but time and labour are saved in reheating the oven; it is also a much cleaner and less laborious operation.

The "Hot-water Ovens" named above effect much economy in time as well as cost of fuel in heating;

they are also very cleanly in operation, and save much labour; the heat given is more uniform and can be more easily adjusted than with fire ovens.

To decide upon the merits of the three systems described, the architect is advised to communicate with the firms above named for the "Gas" and for the "Hot-water" ovens; and for the "Fire" ovens to several firms who have made a speciality of these apparatus. It should be stated that great improvement has been made with this latter class of oven, especially as to their economy in fuel and the time of heating them.

Store Room for Bread.—This must be provided near the oven room; it only requires fitting up with open grid shelves, and that the room should be well ventilated and of good size compared to the quantity of bread to be stored. The room should be so placed that no foul air can get into it from any adjoining room or passage, or from any place at the outside of the building.

Open trucks are employed to convey the bread from the kneading room to the ovens, and to remove the bread from the ovens to the store room, and thence as required to the dining hall and wards, &c. These trucks should run on three wheels, the first one being made to swivel; the wheels should be fitted with indiarubber tires, and the axles of the wheels hung on steel springs.

CHAPTER VIII.

STEAM LAUNDRIES.

THE designing of laundries and their machinery and apparatus requires very careful consideration, the details of the arrangement will vary according to the class of establishment; thus, laundries in asylums, unions, infirmaries, hospitals, and industrial schools, would as a rule be much the same; while in hotels, residential mansions, and kindred places they would differ in many respects; these and public laundries would have much the same arrangement. The descriptions hereafter given will principally apply to the first named class, which often attains to much the same requirements as for the latter class, when a large staff of officers have to be provided for. Whenever possible it will be clearly indicated if any particular apparatus or arrangement can be dispensed with. The architect is advised to get full instructions as to the class of work to be performed, as he will then be better able to decide which of the apparatus hereafter described will be best suited to his particular case. It would be impossible to describe in detail, within the limits of this book, the buildings and apparatus suitable to every case likely to arise.

Laundry for Large Asylums, Unions, &c.—This will now be treated, and every requisite detail given of the plant and its arrangement and working, as well as leading particulars of the buildings. The Laundry should be placed in a separate building disconnected from the main portion; it should be divided into three principal divisions, washhouse, drying room, ironing room and stores. A separate washing room is usually provided for the officers' linen and for the fine things. A separate house or chamber should be provided for dessicating, cleansing, and fumigating infected linen or mattresses, &c.

Washhouse.—This room should be constructed with an open roof, well lighted and ventilated by means of a top lantern as well as by windows on one side of the room; the height of the walls from the floor to the wall plate should not be less than 15 feet. The roof may be constructed in the same manner as described for the kitchen; the walls on the inside should be lined with glazed bricks and the floor covered with tiles set in cement concrete. Inlets of fresh air should be provided at the front walls; the upper part of the side windows may be made to swing and be actuated by adjustable levers and rods. The washing troughs are placed round the room, they are usually made of wood; each should be provided with an outlet plug and washer. Hot and cold water must be laid on to each trough.

The Washing Machines may be placed in the centre of the room, the rinsers in front of them, and the

centrifugal wringing machines near the back wall. The floor of this room must be laid to drain to trapped gullies, which should discharge into a cast iron socket pipe, jointed with lead and placed under ground.

The Drying Room.—This only contains the drying cupboards or chambers; they are placed back to the wall, sufficient space being left in the front of the chambers to draw out the sliding horses and leave beyond a 6-foot passage way. The width of the room should not be less than 14 to 15 feet, and the height the same as the washing room.

The Ironing and Finishing Room.—The mangling and ironing should be done in this room; a long bench or table should be provided for ironing. The mangles can be placed near the back wall, and the driving shaft fixed over them. An open fire or a Sydenham stove may be provided in this room.

The Engine for driving the machinery should be placed at the other end of the building, next the washing machine room, but it must be in a room separate from the other part.

The Boiler must be placed in a house or room close to the engine, but disconnected from it; the details of these houses are the same as before described for like places. Steam may be supplied from any boiler near, should one be in a convenient position. In large places, however, it is advisable to have separate boilers for the laundry.

Plant.—*Washing Troughs* may be wood and placed next the windows of the room; cold and hot water must be laid on, $\frac{3}{4}$ inch to 1 inch diameter cocks and pipes will be sufficient; each trough must be fitted with waste plug and washer, underneath which a solid drawn lead trap, 8 lb. per foot, fitted with a cleaning screw should be placed; a 2-inch diameter lead pipe is attached to the trap and carried away outside the building and delivered *over* a trapped gully; two or more troughs may be discharged over one trap, but long lengths of waste pipe should be avoided, as they become very foul. The washing troughs may be lined with copper $2\frac{1}{2}$ lb. per superficial foot, turned over the top roll of the troughs and nailed to it; they are much easier kept clean when made in this manner, and, taking into account the time they last, are the most economical in the end.

Washing Machines.—The best kind are those made by Messrs. Manlove, Alliott, & Co., and Messrs. Bradford & Co.; they can stand in the centre of the room, and be driven by shafting either placed overhead, or in a tunnel under the room; this latter plan is the best, but is rather more expensive; it possesses this great advantage, that any part of the shafting and gear may be readily got at for repairs or adjustment, also that the wheels and straps are kept out of the room, and so accidents are prevented. The machines are made in various sizes and forms to suit the kind of work they have to

perform; they are usually fixed upon an elevated part of the room, at a sufficient height to command the rinsing rollers and tanks. A draining table and grid is provided under each machine; the clothes are tipped out by reversing the driving gear of the machines.

Wringing Machines.—After the clothes are taken out of the washing machines, they are passed through rolls fixed on a tank; in this machine a great part of the water is taken out, and much time and power saved in the rinsing machines. The top roller of the wringing machine is of copper, and the lower one of wood covered with cloth. A spring actuated by a screw and hand-wheel controls the pressure as required, and is easily and quickly adjusted. The tank is constructed of cast iron, and fitted with a plug and washer at the bottom to empty and clean it out. The size of these machines depends upon the quantity and the nature of the work they have to perform.

Steam Soap and Soda Dissolver.—An apparatus of this kind must be provided, to dissolve the soap and soda; it may be divided into two vessels to dissolve each separately; it is made of cast iron, with interior vessels of copper, steam is admitted to the exterior jacket; this is a much better system than using steam coils in the tank, as in the copper jacketed vessel the heat is got up much quicker, and the trouble caused by the corrosion of the coil is

saved. Each of the compartments is provided with a hinged cover of copper got up bright; the pan is fixed upon framing, and is about 3 feet high. It is a great advantage, and economy in the quantity used is effected by dissolving the soap and soda in this vessel before it is put into the rotary washing machine.

Automatic Rinsing Machine.—This machine consists of a large drum divided into four compartments, each of these have internal feathers; the clothes are loosely placed in these compartments. The drum when loaded is made to revolve, a stream of water flows through it, and is regulated according to the goods to be rinsed. The clothes are well turned over in the compartments, and also well distributed by the internal mid-feathers; every part of them is thoroughly exposed to the water, and they are thus perfectly rinsed. Unless they are well rinsed, they will not be a good colour, added to this they cannot otherwise be made perfectly clean. These machines do the work in a very superior way to the ordinary open tanks. It must be understood a constant stream of clean water is always running through. The drum can either be made of timber bound together by iron hoops, or of galvanised wrought iron; the shaft of the drum is carried in bearings on A-frames of cast iron, and is fitted with driving pulleys, and belt gear. An ordinary machine is about 6 feet diameter; they are, however,

made in much larger sizes for special work; they are constructed by Messrs. Manlove, Alliott, & Co.

Clear Rinsing or Blueing Machines.—These may be used as supplementary to the above machine, and made in the trough form with two divisions; a pair of squeezing rolls is fixed over *each* of them. They may be made of hard wood bolted together with gun-metal bolts and nuts. A false bottom is provided for each compartment, and a large gun-metal cock is fitted to the bottom of each division. The rollers for squeezing (fixed at the top of the troughs) are covered with indiarubber, and set in cast-iron frames, and made adjustable by screws and springs, a brass tube on the feeding side of the rollers is provided to protect the hands of those working it. The geared wheels of the rolls must always be enclosed in an iron case; the rolls are driven by a strap from the main shafting on to fast and loose pulleys on the machine.

Steam Boiling Coppers.—The coppers are either set in a nest of four in the centre of the room, or may be ranged round the side walls. They contain 80 to 100 gallons of water each, and are made of copper plate; they should be placed in exterior casings of cast iron, forming an intermediate space for steam all round the interior vessels. Each copper should have a perforated false bottom also made of copper, and $\frac{1}{8}$ inch thick, the dirt and sediment falls to the bottom of the vessel, and is thus

out of contact with the clothes; each copper should have bright hinged covers, made of copper plate and fitted with chains and counterbalances. Hot and cold water service, 1 inch diameter, must be laid on to each vessel, and a draw-off cock $1\frac{1}{2}$ inch diameter must also be provided. This form of copper is a little more expensive, as to first cost, than a pan with a steam coil inside, but it costs less for steam to work it, heats quicker, and is in all respects the best apparatus to use.

Centrifugal or Wringing Machines.—These may be placed near the back wall, the baskets may be from 36 inches to 42 inches diameter, machines with 54 inches and 60 inches diameter baskets are sometimes used for large things; they are driven at a high speed by means of straps from the shafting, and should be protected by an iron cage round them, to prevent anyone being injured. In some instances the machines are driven by a steam cylinder attached direct to the side of the outer pan, the steam being taken from any steam pipe near, or in a small pipe direct from the boiler to the machine.

Drying Chambers.—The number of these must depend upon the amount of linen to be dried. The chambers are made about 7 feet 6 inches to 8 feet long by 1 foot 8 inches to 2 feet wide; the front and sides are cast iron, the wall of the building may form the back. The sliding horses are constructed with cast-iron plates back and front and nine or

more hollow galvanised iron rails fixed between them, and run on four cast-iron wheels on two rails; when the horses are fully drawn out, the back plate of each forms a door to the chamber. Rails are provided at the floor for the horses to run on. The floor of the chamber is covered with perforated plates, which rest on top of the channels in which the steam-heated pipes are fixed. It is sometimes advisable to place the heating pipes above the floor, either along the back of the stove and up each side of each chamber, or at one side only. When they are sunk in channels the latter must be lined with glazed bricks, and every facility must be provided to keep them clean; if not well attended to in this respect they become foul and may infect the linen. Good ventilation must be provided at the top of the hot chambers, and also at the lower part, both being capable of regulation; the success of the drying chambers very much depends on the attention given to the ventilation.

The quantity of steam pipe 4 inches diameter required is about 200 to 220 feet run for each 1000 cubic feet of space to heat to 85°. The pipe coils are put together in the same manner as described at p. 63 for steam heating; proper condense boxes must be provided, and means for taking away the condense water. Valves are supplied to regulate the steam in each set of coils. Thermometers must also be provided to show the heat of the chambers. Steam heating is more satisfactory and costs less

to work than hot air; added to this there is no risk from accidental overheating of the flues, which sometimes takes place in the latter system.

Mangles.—Box mangles are more generally preferred, roller mangles may, however, also be provided, as they suit some classes of linen; the box mangles do sheets, table-cloths, and other wide things the best, and put a better gloss upon them. The number required will of course depend upon the class of linen to be treated, as well as the quantity. The machines may be placed near the back wall, and be driven by an over-head shaft and pulleys. The size of the box mangles for large places should be 8 feet 6 inches by 3 feet 3 inches; this machine is driven by the shafting; it is automatic in its action and when once started requires very little attention. The roller mangles are made in various sizes, those with rollers 3 feet long are suitable for large places. The rollers are made of hard wood about 7 inches diameter, set in a cast-iron frame, with hand-wheel, screw, and spring to regulate the pressure. The machine is driven by a belt from the shafting on to fast and loose pulleys, with fork gear for starting and stopping; the rolls are driven by tooth wheels, which are encased in iron boxes to save accident; a guard rod must also be provided in front of the rolls, to prevent the hand of the worker being drawn in.

Calenders.—These are heated by steam, and are

very useful for table and other linen; they are made in various sizes. The rollers are from 6 inches to 9 inches diameter and 32 inches to 72 inches long, they are driven by the shafting. Calenders made with endless bands enable one person to calender average-sized things without any assistance. The bottom roller can be lowered instantly, if desired, by actuating a lever with the hand; this allows space between the rollers for things having buttons attached to pass through without injury. The rollers of a machine suitable for large places are about 48 inches to 54 inches long.

Ironing Machines.—These machines are made in various sizes; a length of 72 inches represents a size that is suitable for large places. They are made up to 120 inches long for special cases, and with rollers 3 feet 6 inches diameter; this latter is a very powerful machine and is not likely to be often required. In all these machines the ironing surface is a concave polished dish, hollow, and heated by steam; the linen is pressed down on it by a roller covered with a wrapping of flannel. The pressure is made adjustable at will, and can be immediately lessened so as not to injure any delicate part. The pressure of steam required is about 50 lbs. per square inch. It is driven by steam power, and is made automatic in all its movements. These are rather costly apparatus, but in all large establishments they should be provided; great saving in labour is effected, and

the number of assistants in the ironing department is much reduced. These machines are useful for ironing and finishing muslin curtains, and like kind of things; the smoothing can be done at one operation; not only is much time saved, but the work is done much better in every way, the things are made to look equal to new. The requirements of the establishment to be treated must be ascertained, especially as to the length and kind of linen, &c., to be ironed, and a suitable machine selected; those best adapted for asylums and schools are different from those required at hotels and residential mansions. Messrs. Manlove, Alliott, & Co. make a large variety of this kind of machine suitable for every purpose.

Ironing and Finishing Machines for Collars, &c.—These machines are sometimes used, but not always in places where they want to find employment for the female inmates. They are made in several sizes and to suit different kinds of work. All kinds of linen, such as shirts and collars, can be done by this machine. The irons may either be heated by gas or steam, the pressure of the iron can be adjusted at the will of the operator. A double machine will do about 180 dozen of collars or cuffs per day of ten hours.

Gas Stoves for Heating the Irons.—These are the best to use, a more even and regular heat is obtained than from an open fire. The heaters are

made to take from 12 to 30 or more irons at one time; the cost of heating the irons is less than when coal is used in stoves for the same purpose. Small cylinders heated by gas or steam are also employed for ironing small things. Gas-heated irons are also used, these are suitable for large linen.

Radial Drying Horses.—Two or three of these are necessary; they are handy for small things, and are light and easily moved. The arms are about 30 inches to 36 inches long, and about 18 to 24 in number; they are made of galvanised iron, and work round a central vertical rod or column, and can be set to any desired position. The base of the standards should run on three swivel wheels. They may be placed either side of the stove used for heating the irons, or before an open grate.

Drying Grounds or Courts. — Separate yards or courts, either covered with grass or paved with asphalte, should be formed. The drying posts are cast iron, and in some cases are fitted with pulleys to raise and lower the lines; in other instances the lines are galvanised wire, and are fixed to the posts The posts may be painted to preserve and keep them clean, they are usually fixed in rows, with ample space between each to afford a passage-way for the trucks containing the linen to pass freely. The paths or passages should be formed in tar paving or asphalte, and be well drained. Care should be taken to provide enough room in these airing courts,

as a large proportion of the linen can be dried outdoors in good weather.

Engine for the Laundry.—The size of this will depend upon the number of machines to be driven; taking the inmates at about 1000, the power to drive the machinery in the laundry department will be about 10 horse-power nominal. The most suitable engine is one of the horizontal type, high pressure, say 10-inch cylinder by 21-inch stroke, and driven at a speed of 70 revolutions per minute. A Porter's patent governor should be provided, but no feed pump is necessary. The pressure of steam may be 40 lb. per square inch; it can either be supplied from the central boiler house, or taken from a boiler specially set apart and fixed at the laundry. The power from the engine is taken by a leather belt to the shafting which drives the washing machinery.

Boilers.—When separate ones are placed at the laundry department, they should be close to the engine, but in a separate house. The size of the boiler necessary for the engine named should be 4 feet 6 inches diameter by 14 feet long and 2 feet 4 inches tube, of the Cornish type, set in brickwork. A duplicate boiler should be provided. A steam feed pump should be fixed in the boiler house, also an injector, a feed water heater, and small supply tank. The boiler must be arranged in the same manner as described in Chapter IX., at p. 126. All the steam

pipes from the boiler to the engine and to the washing machinery and drying stoves must be covered with non-conducting composition; Leroy's is the most suitable. The pipes should also be fitted with proper expansion joints and condense boxes to keep them free from water. The pressure of steam may be reduced by passing it through a valve for this purpose; after the pipe leaves the engine 20 lb. per square inch is sufficient for all the other work, some people even prefer less, but for the drying stoves sufficient heat cannot easily be maintained withless pressure.

Steam Pipes must be run under the floor in a brickwork channel to the drying chambers, to heat the pipe-coils; also to the steam calenders. The pipes in the channel must be covered with non-conducting composition, and well painted. The diameter of the pipes may be 5 inches or 6 inches, according to the number of chambers to be heated. Flange pipes with faced joints should be used for this purpose.

The Disinfecting House.

This may be arranged in two separate rooms, one for receiving the foul linen, and one for delivery of the same when cleansed. In the first department the special van containing the linen, &c., to be disinfected should have room to draw in, a space of 8 feet wide should be allowed for this. A small boiler to supply steam may be placed in one corner of this

room. The disinfector should be placed at the division wall of the room, and in the centre, with one end of the cylinder entering the next room; it is provided with a door at each end. The infected goods are received in the first room, put into the cylinder, and when completed are delivered into the finished or "disinfected" room. By this plan all danger of contact between foul and cleansed goods is avoided. The first room may be 22 feet long by 15 feet wide, the second one say 12 feet by 15 feet wide, and the height of each to the wall plate, say 12 feet. Free ventilation, especially in the first room, must be provided.

The Apparatus best suited is "Lyon's Patent Chamber," made by Messrs. Manlove, Alliott, & Co. It consists of a horizontal steam-jacketed wrought-iron cylinder, having a cast-iron steam-tight door at each end. An open trough made of wire work slides upon two bars in and out of the machine. Standards are fixed to each end, and on these a cross-bar carrying rings or hooks to hang up clothes, &c. At each end of the machine two bars are placed outside, and on these the wire trough, which is hung on wheels, is run out; it thus allows the goods to be put in at one end and drawn out at the other without any communication being made between the rooms. The outside of the cylinder is protected by felt and wood lagging; suitable provision is made for the inlet of steam and outlet of condense water. The steam can be admitted either into the

jacket or the cylinder, a moist heat of about 250° to 260° is obtained without any risk of injury to the goods operated on. The process takes from one hour to one hour and a quarter, according to the goods and their state. The steam can be taken either from a boiler placed in the first room, or from one placed near; the pressure required is about 30 to 40 lb. per square inch. The vans and men *taking away* the cleansed goods from the chamber should be separate from those bringing it.

Experience has proved that steam heat under pressure in a closed iron chamber, where the air is compressed, allows the steam to force its way through mattresses and bedding; it absolutely cleanses the interior, and destroys any form of life, existing in them. In the same way the germs of disease in them are also absolutely destroyed. In some cases it has been found advantageous to use steam of a higher temperature in the jacket than the interior of the cylinder; the open steam in the latter portion is thus slightly superheated.

This Disinfecting Room and Apparatus is only required in asylums and public industrial schools, workhouses, and other places of like kind. It is a most necessary department in all these establishments, and care should be taken to isolate the building from all other parts of the place. The building should be constructed in brickwork, the walls 14 inches thick, and lined with white glazed bricks; the floors should

be laid with Stuart's patent granolithic paving; the roof constructed with iron trusses close boarded, felted, and slated, the boards plastered on the underside, finished in Keen's cement, and painted. This manner of construction permits of the periodical washing down and cleansing of all parts, a very essential thing in such a place. The dimensions of the rooms noted above are suitable for ordinary places, the exact requirements should be ascertained, in case they may not be suitable to the particular case. The window frames should be iron, glazed with thick dull glass; the tops of the sashes made to swing, and operated from the floor of the room by levers and rods.

Hot and Cold Water Supply should be laid on, and fitted with cocks and indiarubber hose, for the purpose of cleansing the place; some of the water should be made to run into a small supply tank of about 150 to 200 gallons, containing disinfectants, and from this a supply may be taken by the hose for use as required.

CHAPTER IX.

ENGINES, BOILERS, AND PUMPING MACHINERY.

The engine power is principally wanted for pumping purposes, as in most large places separate engines for the bakery, laundry, and other departments are provided at or near their respective localities. The engines for pumping are usually placed in the well room, or very close to it, and are, where possible, geared direct to the crank shafts of the pumps, which are placed at the top of the well. The size of the engine must be regulated to the quantity of water required and the height to be lifted. Assuming the number of inmates at say 1000, and that the level of the water is within 100 feet of the surface, and the total height to be pumped does not exceed 160 feet to 180 feet, the cylinder of the engine may be 12 inches diameter by 24 inches stroke, and be driven at a speed of 70 revolutions per minute with steam at a pressure of 40 lb. per square inch. The horizontal type is the most suitable form; it should be placed with the crank shaft in a position to gear direct to the well pump crank shafts.

The following are the leading dimensions of the engine: cylinder, 12 inches diameter by 24 inches stroke, thickness of metal, $\frac{7}{8}$ inch, piston, 4 inches

deep, piston rod, steel, $1\frac{7}{8}$ inch diameter, the slide rod, steel, $1\frac{1}{8}$ inch diameter, connecting rod 3 feet 6 inches to 4 feet long, made of steel, with solid gun-metal ends; crank disc, cast iron, turned all over and well balanced; expansion gear and eccentrics with gun-metal straps; governor, Porter's patent; fly wheel, 8 feet diameter by $6\frac{1}{2}$ inches wide, turned on the rim and edges, the weight of the wheel to be about 25 cwt.; stop valve, $2\frac{1}{2}$ inches diameter, crank shaft, $4\frac{1}{4}$ inches diameter by $5\frac{1}{2}$ inches wide at the bearings; the lagging of the cylinders, mahogany staves 2 inches wide by $\frac{3}{4}$ inch thick; condense cocks, $\frac{3}{4}$ inch diameter; steam pipe, 3 inches diameter, exhaust pipe, 4 inches diameter; spur pinion on crank shaft to drive pump, 12 inches diameter by 6 inches wide by 2 inches pitch, gearing on to a mortise wheel on the pumps, 2 feet 9 inches diameter by 6 inches wide. The size of the bed plate is 10 feet 6 inches by 2 feet 2 inches, by 5 inches deep; the main bearing to be made of phosphor bronze.

The engines should be in duplicate. In cases where there is sufficient room a condensing engine should be used; the air pump and condenser in this case are placed at the back of the cylinder, and worked off the piston rod.

The engine must be fixed upon a good foundation of brickwork, resting on, say, 24 inches of concrete. At the top of the brickwork a stone 12 inches thick must be provided; the holding-down bolts should be $1\frac{1}{4}$ inch diameter, and passed through the bed plate

and through $1\frac{1}{2}$-inch diameter tubes built in the foundation; the bolts are about 3 feet 6 inches long, and are secured at the lower ends by cottars and plates. The top of the stone is made dead level. The bottom of the cast-iron bed plate of the engine being planed, the truth of the engine can be assured; when the bed plate is bolted down the holes of the bolts should be run with Portland cement grout. Upon a sound foundation the good performance of the engine mainly depends.

Well Pumps.—Two sets of three-throw pumps should be sunk sufficiently low in the well that the suction valves may be within 25 feet of the *lowest* level of the water. Space must be left between each set of pumps, for men to get down to examine and repair. The pump barrels may be 6 inches diameter by 18 inches stroke; at a speed of 25 revolutions of crank they will deliver 6600 gallons of water per hour. The barrels should be made of gun-metal, $\frac{3}{4}$-inch thick, and the buckets and valves of the same material, the rods of copper, the crossheads and the upper parts of the rods of steel. The suction and rising main 6 inches diameter, and the air vessel say 16 inches diameter by 4 feet 6 inches high. The pump rods are guided at each 6 feet to 7 feet by rollers working on pins in bearings attached to light girders fixed in the side walls of the well. The crank shaft should be steel, 5 inches diameter, and the pins 5 inches diameter also, and at the end a spur wheel

is keyed on, working into a pinion keyed on the crank shaft of the engine. The engines must be so arranged that either of them can work either set of pumps as required. The pumps are hung by flanges cast upon the delivery valve box on girders fixed across the well; the lower part of them hangs quite free.

Ladders are provided to go down the well, and when it is deep, stages of wood or perforated iron plates are provided for safety, to prevent anyone falling from any height into the water. Ample means should be afforded for easy examination and repair of any part of the pumps or their gear.

Tanks.—The water from the well should be lifted into tanks placed over the engines, *under* the roof of the house. The tanks are made of cast-iron plates, with planed flanges, jointed and bolted together; the size of the plates should not exceed 4 feet by 4 feet, and the depth of the tank not more than 4 feet. The tank should be supported at each joint by wrought-iron girders, and be provided with an overflow pipe and other fittings, as described at p. 44. The contents of the tanks should be about two to three days' supply. They may be lined with glazed bricks. If from any cause they must be placed outdoors, they should be provided with a tight wood cover, made of $1\frac{1}{4}$-inch boards in two courses, with felt placed between them; a manhole, fitted with a hinged door, should be provided at one corner of the cover. The tanks in this case may have light

galvanised iron roofs placed over them, to protect them from the weather. It is advisable to provide the tanks in sections, to insure that there are some always available for use while the others are being cleaned out or under repair. The water is pumped from these store tanks to those at the top of the building as described at p. 42, by the pumps next detailed.

Pumps.—Those used for the above purpose are made in sets of three, set in a cast-iron frame, and worked by a wrought-iron or steel three-throw crank. There should be two sets = six pumps. The barrels are gun-metal, 6 inches diameter by 18 inches stroke, and $\frac{11}{16}$ inch thick, and when worked at a speed of 25 revolutions per minute of the crank, will deliver 6600 gallons of water per hour. These pumps in large places should be worked by separate engines, of the same type and dimensions as described for the well pumps. The pumps should be in duplicate; and should deliver into one rising main, on which should be fixed a large air vessel made of copper $4\frac{1}{2}$ lb. per foot, 14 inches diameter by 4 feet 6 inches high. A safety valve must be placed on the pipe near this, to give relief in case of undue pressure. A counter should be placed in the pump room, to indicate the quantity pumped, added to this a tell-tale recorder or indicator may be fixed to show from hour to hour the working of the engine and pumps.

The crank shaft of the pumps is provided with fast

and loose pulleys, 36 inches diameter by $6\frac{1}{2}$ inches wide, and is driven by a leather belt 6 inches wide; fork gear is fitted to throw them in and out of work. The suction and delivery pipes are 6-inch diameter cast-iron, faced flanged pipes. The pump rods are copper, 1 inch diameter, at the lower part, and steel at the guides and crossheads, and the connecting rods wrought iron, with solid gun-metal ends. Each pump has separate suction and delivery valves, with hand holes and covers opposite each for examination and easy removal in case of any failure, or when any repairs or renewals are necessary. Pumps of this kind should always be made by first-class firms. All the leading dimensions and particulars should be clearly stated by the architect, to ensure that good work only is obtained, and that it is carried out in a proper and substantial manner.

Size of Pumps.—It is not advisable to use pumps larger than those above described; when more water is to be pumped than these will discharge, the number of sets should be increased, taking care that one *duplicate* set is always retained for use in case of emergency. Pumping water for the large places now under consideration is an important thing, and should have great care in designing and laying down the proper machinery, well fitted for its purpose, and not liable to break down and cause expensive repairs and endless trouble to all concerned.

An electric tell-tale, to show when the tanks are

full should also be provided; these apparatus are reliable in action, and are made by Mr. G. Jennings, of Lambeth.

The number of sets of pumps for raising water to the tanks placed on top of the building depends upon the quantity required. Two sets, one for a duplicate, should always be provided.

High Pressure Hydraulic Pumps.—In the event of power being required to work lifts at a high pressure direct from the mains, a pumping engine of a special type must be provided, in addition to the ordinary pumping machinery. The engines and pumps are horizontal and fixed on the same bed-plate, and pump water at a pressure of 650 lb. to 700 lb. per square inch; the water is delivered into an "accumulator," consisting of a ram and weighted cylinder or cage, by which means the water is kept at a constant pressure in the mains which are laid down specially for this purpose. A safety valve is provided on the main pipe close to the "accumulator," to take off any undue pressure; the mains should be 4 inches diameter by 1 inch thick, and be carried underground to the machines as required. Valves are provided to shut off any sections of the service where power may not be wanted. As this is rather a complicated subject, an outline only has been given; should any further information be desired, the reader is referred to the author's book upon 'Hydraulic Lifting Machinery,' E. & F. N. Spon,

London, where the matter is treated in full detail. This class of machinery is not as a rule used, except in very large places, and then only when above half a dozen to a dozen lifts are wanted. The power may be adapted for many other purposes, such as for hauling trucks in the coal-yard, and driving small hydraulic engines, where power may be wanted at some distance from any steam boiler.

Boilers.—These should be placed in a separate house; in small places the steam for the pumping engines may be taken from the central boiler-house, but in large ones it is advisable to place separate boilers next to the engine house in another room.

The best kind of boilers is the Cornish type; they should be in duplicate, 5 feet 6 inches diameter by 16 feet long and 2 feet 8 inch tube; this will give a good reserve of steam and enable two engines to be worked at the same time. Feed pumps and injectors, as well as heaters for feed-water, should be placed in the boiler-house. In some instances these boilers may be near the laundry and other departments requiring steam; when this is the case, they must be made larger and of the Lancashire type, say 6 feet 6 inches diameter by 18 feet to 20 feet long, and two 2 feet 6 inch tubes, or 7 feet diameter by 24 feet, and two 2 feet $8\frac{1}{2}$ inch tubes; it is not advisable to use any larger diameters than the latter; it is better to add to the number of the boilers when more power is required.

The boilers are set in brickwork, about 8 feet must be left in the front to give room for stoking, and room for coals at the side of one of the boilers, or a coal bunker may be formed at the front above the stoking place; both boilers may be taken into the same shaft, or, if any is near serving other boilers, it can be used. If flues have to be conveyed underground, great care must be taken to ensure that they are dry and free from damp and moisture; the exterior should always be coated with Portland cement concrete; the flue should also rest upon a good bed of the same. No sharp angles must be left, or any place where it is possible for air to enter.

Fire Pumps.—In small institutions where the boiler and engine-house are central and near the main buildings, a steam fire pump may be provided; a Duplex pump is the best for this purpose, the pump being made to suit the height the water has to be forced, as well as the quantity required. They should always be under steam and ready to start at any time; the delivery pipe should be carried to any convenient spot where leather or indiarubber hose can be quickly attached; the pipe should be $2\frac{1}{2}$ inches diameter, and the nozzle at the end screwed to the Metropolitan Fire Brigade standard; it will thus suit any hose. See also Chapter IV. for remarks upon fire mains and means of extinguishing fires in buildings.

For additional detailed information upon engines,

boilers, and pumping machinery, the reader is referred to the author's books—'The Modern Steam Engine,' also 'Pumps and Pumping Machinery': E. & F. N. Spon, London. Types of engines, &c will be found in them to suit every case likely to arise in any architect s practice.

CHAPTER X.

STABLES, COW-HOUSES, WORKSHOPS, ETC.

Stables.—As horses are required, as a rule, at asylums, &c., especially where any farming is carried on, a few hints as to the best form of construction of stables may be useful; they may be built with a room over for a corn and hay store; the stable should be lofty, well lighted, ventilated, and drained. As an example, a stable for ten draught horses will be described.

The dimensions should be 72 feet by 17 feet, by 14 feet high to the wall plate of the roof; the walls of 14 inches brickwork; the floor of the stable should be 6 inches to 9 inches above the ground line outside. The height of the room above the stable should be 7 feet 6 inches from floor line to the wall plate. The roof should be framed in timber; the trusses 8 feet 6 inches apart; the rafters close-boarded, felted, and slated. The floor joists should be 9 inches by 3 inches; this will permit corn to be stored in bins or sacks on the floor. The stalls 6 feet 8 inches wide, centre to centre, by 10 feet deep, by 6 feet 6 inches high; the divisions formed of ironwork at top and bottom, filled in with 1 inch grooved and tongued boards; the manger should be cast

iron, enamelled inside, and the racks wrought iron. The paving should be Stuart's patent granolithic concrete, laid and drained in the way described at p. 37; the window frames should be wrought iron and glazed with thick glass, the top of the sash to be fitted with swing panes to give air and ventilation. At the manger end four ventilating tubes should be carried up through the roof, "hit and miss" ventilators should also be provided for the inlet of fresh air at each stall; the stable should be perfectly ventilated without making any draught. At one end of the stable a harness room should be provided; this should have a fire-grate in it; the size of the room 17 feet wide by 15 feet long. Water should be laid on inside as well as outside the stable, and a steam pipe from any convenient boiler provided inside, also a suitable kettle to make hot mashes, &c., for the horses.

The ceiling of the stable may either be plastered or match boards nailed to the under side of the joists; two loose boxes should be provided; these may be 13 feet 4 inches wide, centre to centre, by 10 feet deep. Shoots from the upper floor for hay and corn should be provided, also a corn bin made of deal lined with zinc and fitted with a hinged cover. The upper floor need not run more than 25 feet or 30 feet over the stables; this will give room for all the fodder that need be stored, and also for chaff-cutting and other machines.

A platform or paving laid with granolithic con-

crete, say 9 feet wide, on which to wash the horses' legs, should be provided outside the stable, this work should always be done outside and *not* in the stable.

Coach House.—This should be attached to one end of the stables, and made about 15 feet wide by 17 feet deep, this will take two vehicles; and outside this an open shed for carts should be constructed; this may be about 28 feet long, and the same width as the coach house. Water should be laid on for washing the vehicles, and a paving of granolithic concrete formed outside the coach house 10 feet wide. This paving should fall to the centre to a trapped gully, fitted with a dirt box connected with the drain pipes of the stable system.

A dung pit should be provided outside the stables to take about a week's refuse. It should be built in brickwork, paved on the bottom, and fitted at the top with an oak frame and deal door hung on hinges. The pit should not be made too deep; it should be laid to a fall at the centre, and drain into a trapped gully connected with the drain pipes of this system.

A shed for carts and agricultural machines should be constructed at a convenient position, and of dimensions suitable to the requirements of the place, and in cases where any agricultural machines of large size are likely to be used, the shed must be made higher than for carts only.

Cow Houses.—These buildings do not require

any upper storey. The walls may be 14 inches thick and 13 feet to 14 feet high from the floor line to the wall plate. The top of the floor should be 6 inches above the ground line. The interior paving should be Stuart's patent granolithic; if the bottom is good, concrete need not be used; the granolithic in this case is formed directly on dry core of broken bricks or stone, the thickness being about 4 inches. The roof is framed in timber, the trusses 9 feet apart, the rafters covered with grooved and tongued boards 1 inch thick, and covered with Croggon's inodorous felt, well lapped and nailed. The roof should be covered with Duchess slates laid to a lap of 3 inches, and fastened with two copper nails each, the ridge covered with Williams' patent roll and saddle back. The under side of the rafters should be plastered. Ventilators should be fixed in the ridge of the roof, say about 9 feet apart. Inlets for fresh air, capable of regulation, should also be provided at each stall.

A single house for 20 *cows* would be of the following dimensions: 75 feet long by 16 feet wide by 14 feet high. The stalls may be made of iron about 7 feet 6 inches wide and about 9 feet deep, to take two animals each, or if close economy must be studied, they may be constructed entirely of wood; the stall posts of oak, 6 inches by 6 inches; the sill of oak, 4 inches by $4\frac{1}{2}$ inches; the cap of oak, 4 inches by $4\frac{1}{2}$ inches; the panelling $1\frac{1}{2}$ inch deal boards, grooved and tongued; the mangers of cast

iron, resting on the floor; and the racks of wrought iron. The floor of the stalls should be laid to drain at the centre of each into a cast-iron trapped gully; a gutter may be formed in the paving in the centre of the space between the end of the stalls and the wall of the house.

A double house may be constructed with double stalls, which may either be arranged in lines against each wall, or placed in the centre of the house, end to end, the passage on each side being between the back part of the stalls and the side walls of the house. In a house of this description a stall should be left out in the centre, and also one at each end of the house, to form passage ways, or the stalls may be placed each side of the house, and a 4-foot way for feeding left between the end of the stalls and the walls. A room must be divided off at one end of the house for the fodder; the size may be about 13 feet by 16 feet. Water should be laid on with $1\frac{1}{4}$ inch pipes, and taps to draw off at intervals, the nose of each tap being screwed for hose connections. The floor must be laid to falls, and be provided with trapped gullies to keep the house clean and dry; it should also be well lighted, the window frames and sashes of wrought iron fitted with swing sections at top of each; the glass should be Hartley's rough plate.

A dung pit should be formed outside the house, this must be covered over. It should not hold more than one day's refuse, and should be regularly

cleared out and put on the land or removed to a place where it cannot cause any smell or nuisance.

The structure must be so built that it can easily be kept clean and in a perfect sanitary condition. There is no reason, provided that proper provision has been made, why cow houses should not be as clean and sweet as other places. Where a large number of cows are kept, a separate house to accommodate two or more should be provided, for a hospital to move the animals to when sick. When the house is not large, and in cases where the extra expense is not objected to, the walls may be lined with glazed white bricks. A house constructed like this can be very easily kept clean; the extra amount expended on the construction well repays the outlay; the walls only require to be washed down, and no expense is incurred for whitewashing except the roof of the place. A pavement of granolithic should be formed outside the house about 8 feet wide; water should be laid on at this part, and two open tanks of cast iron, holding about 200 gallons each, should be provided; they may stand about 2 feet above the pavement, waste plugs should be fitted to the tanks so as to clean them out. Draw-off cocks must be provided at each tank.

The perfect sanitary condition of the houses is a matter of the greatest moment to the health of the patients or inmates of the institution who are supplied with milk; much illness and disease having been, in many instances, traced to a want of cleanli-

ness in these places, as well as allowing infected animals to remain in the same house as those that are in good health.

Piggeries.—These places are best constructed of cast iron. The outside open enclosures should be the same, and fitted with wrought-iron gates. Those made by Messrs. Musgrove & Co. are suitable, and answer their purpose well. Each pig house may be 6 feet wide by 8 feet 6 inches to 9 feet deep, the paving should be raised about 6 inches to 9 inches above the general ground line to keep them dry; it may be laid in Stuart's granolithic concrete, open gutters being formed in it and laid to falls to suitable gully and dirt traps. The styes are best placed in a line, with their backs to a wall. Every part should be constructed to permit of its being easily cleansed. Water should be laid on, and ample means provided for washing down. There is no reason why these places should not be kept clean and in a perfectly sanitary state, they are too often allowed to fall into a very dirty condition, and thus cause unnecessary nuisance. The feeding and water troughs should be of cast iron, and an iron bin should be provided under cover to keep the food in. A copper and furnace should also be provided in the same place to boil food when necessary. A good and compact arrangement is to make the styes back on to a wall on either side, with a passage, say 6 feet wide, between the outer enclosures. A gutter should be

formed at the side of each enclosure to keep the footway dry. At the end of the centre way the food house may be placed, this may be 8 feet wide by 8 feet by 8 feet 6 inches high, constructed with brickwork walls and timber roof, slated.

The drainage of the stables and the cow houses, &c., should go into a separate system, as described at page 37. It should have no connection at any part with any of the house drainage. The gullies in the yard should have large dirt boxes, and be well trapped.

DAIRIES.

Cream Room.—This room should be built with 14-inch walls, and lined on the inside with white glazed bricks. A "dado" and string course, of blue or chocolate colour, should be run round the room, the former about 4 feet above the floor, this breaks the glare, and relieves the eyes of those working in it; a band or frieze may also be formed at the top of the room next the wall plate. The floor should be covered with coloured tiles laid on a bed of Portland cement concrete and set in cement. The roof should be framed in wrought iron; the rafters wood, and covered with close boards 1¼ inch thick, felted and slated, the under side of the rafters plastered, finished in Keen's cement, and painted. A ventilator should be provided in the roof, and also ample inlets for fresh air. A slate slab, say, 2 feet 9 inches wide by 1 inch thick, should run

round the room for the milk pans to stand on, if possible, the windows should be on the north side; any windows that must open to any part where the sun may get in must be protected by wood louvre shutters hung upon hinges. Sliding shutters are not suitable; they are often very troublesome in working, and cost more to keep in repair. Water pipes and cocks, 1 inch diameter, must be laid on in suitable positions, and connections for indiarubber hose provided. These rooms should *not* be in direct communication with any other, this is for the purpose of avoiding any risk of contamination to the cream from foul air or vapour.

Churning and Butter-making Room.—This must be placed next the room last described. It should contain revolving churns, cream separators, and milk coolers. The size of the room must depend upon the work to be done. This will vary very much, as in some places nearly all the butter is purchased from outside contractors. Assuming that three churns are sufficient, they should be placed in a line in the centre of the room, and either be driven by shafting worked by a steam engine near, or by a hydraulic engine worked by the upper water tank. Rigg's patent hydraulic engines are suitable for this purpose. The room should be constructed in the same manner as the last. The floor of this room must be laid to falls, and trapped gullies provided to take away the waste water; cast-iron pipes, jointed with lead, must be laid

under the room, and connected with drain pipes outside, or the floor of the room may fall to the front wall to an open gutter sunk in the paving, and the waste water run away by means of an iron pipe at the end, and discharged over a trapped gully outside the house. There must be no *direct* communication with the drains on any account. A slate slab 1 inch thick, and say 2 feet 9 inches wide, may be provided on one side of the room for the butter, with sinks formed in it in convenient positions. Hot and cold water should be laid on, and every convenience supplied for keeping the place clean. This room must be kept quite independent from the cream room —that is, no door of communication should be made; a covered way outside the building may connect the two rooms. It need hardly be said that the position of the dairy, where it will be open to the fresh air, and be quite free from any effluvia or bad air of any kind, is an imperative necessity, and must always have the attention of the architect.

A shed, open at the side, should be provided, where the milk cans, &c., can be washed. This must be paved in the same manner as the stables and yard (see page 130). Hot and cold water pipes, cocks, and hose must be provided here. The paving must be laid to fall to trapped gullies connected with the waste water drains. If a steam boiler is near, a steam pipe can be laid on to this shed, and a cone apparatus provided for occasionally steaming the cans—this absolutely cleanses them.

Workshops for Mechanics.

In all large places a staff of mechanics and assistants is employed to do all the small repairs. Provision should be made for smiths', carpenters', upholsterers', and painters' shops, and also sheds for storing building and other materials.

The smiths' shop should be provided with a double forge and bellows, a workbench, and two or more vices, also a small drilling machine and a lathe. These two machines may be driven by any convenient engine, probably the pumping engine. The size of this room may be about 28 feet by 16 feet wide by 14 feet high, made with an open roof, the trusses of wrought iron, boarded and slated, and a cupola at the ridge to take off the smoke. A fan may be provided for working the blast, and be driven by the shafting used for the other machines.

Carpenters' shop.—This may be made of sufficient size to take two or three double benches; in very large places as many as six may be required. The room may be about 18 feet wide by 20 feet long by 14 feet high to the wall plate. The floor should be covered with $1\frac{1}{4}$ inch boards on joists; the floor line should be 6 inches above the ground line. Water should be laid on, and fire-hose kept in the room; fire buckets should also be hung up in the same manner as described at page 47.

A shed open on one side should be placed next

this shop, fitted with timber racks; this place can also be used as a store place for lumber and spare things.

Shed for Building Materials.—A shed, open on one side, about 12 feet high and about 15 feet by 20 feet, may be provided. The walls may be 9 inches thick. Open racks made of timber should be fixed round three sides for stacking small things.

A smaller shed should be placed next the above, closed on all sides. This is for a lime or cement store, both of which require to be kept from the air and damp. Very little light is required in it.

A rack for ladders placed horizontally should be provided with wood roof and weather valence on each side. The ladders should be secured by chains and locks to the stand, so that they cannot be moved by any unauthorised person, and also to insure that they are in their place in case of any emergency.

A rack for scaffold poles and boards, &c., should be provided, and covered by a lean-to roof. Galvanised iron is a suitable and cheap covering.

Workshops for Tailors, Boot Makers, &c.—It is also necessary to provide workshops for these and other trades, but as the chief features of these shops are that they should be well lighted, heated, and ventilated, only a few details are necessary. The size of each shop will depend upon the number of men to be employed, and the nature of the work;

as a rule, the height of all these shops should not be less than 12 feet to 14 feet. They should be well lighted, on the north side if possible, and at the roof a glazed lantern, fitted with swing sashes, should be provided. Simultaneous opening gear, operated from the floor of the room, should be fitted. The walls of these rooms should either be lined with white glazed bricks, or be plastered and painted; by these means they are more easily kept clean. The under side of the roof should always be plastered, and either painted or whitewashed. All these shops should be warmed by hot-water pipes from any convenient hot-water boiler. Coil boxes should be used; the temperature of the rooms should be about 56° to 60° F.

Workshops of this kind may be grouped together; if possible, they should be separated from the main building. When placed in a line, they may be connected by a covered way open at the side. The mechanics' shops should be placed in a yard communicating with the resident engineer or surveyor's office, the pumping room, and the main boiler house. This department should be placed a short distance from the main building, but so that supervision is easy. The electric plant rooms (when any are provided) may be placed in the same yard. The gas works should be placed some distance away, so as to avoid any nuisance.

Water Closets and Urinals should be provided at

each of these departments, and placed at a convenient distance. They should be constructed and fitted up in the same manner as described for workmen a p. 10. Ample automatic water supply should be provided, and every provision made to ensure cleanliness.

CHAPTER XI.

GAS WORKS AND LIGHTING.

In large institutions in the country it is usual to construct gas works for the supply of gas used in the place. The capacity of these works will depend upon the number of inmates, and also upon the amount of external lighting and what is required for cooking and heating purposes. A gas works will be described suitable for an asylum of about 1000 inmates. A slight outline of the process of manufacturing gas is also given, from which the arrangements required in the apparatus can be better understood.

Site of the Works.—When choice can be made, they should be placed as far away as possible from the dwelling portion of the institution, and at or about the lowest level of the premises; if possible, by the side of a water-way or a line of railway. The delivery of the coal and getting rid of the coke economically is a most important consideration. The level of the works must, however, be so placed that flooding is practically impossible, added to which, if the low ground is damp or boggy, the cost of the foundations will be very much increased. The easy

delivery of lime and purifying materials is also to be thought of, as well as the removal of tar, ammoniacal liquor, and the refuse or spent lime. In some cases the latter material, when any farming is carried on, may be put on the land.

Water for the Works.—An ample supply must be provided, for use in the boilers, quenching the coke, washing down, and for other purposes. A tank should be provided and placed in an elevated position, sufficient to command and give a good pressure at all parts of the works and apparatus. It would also be used for extinguishing fires in this department; the same arrangements should be made as to pipes, cocks, and hose as described at p. 48.

Drainage.—Attention must be paid to this, and the drain pipes kept quite separate from the general sewage of the place. The disposal of the gas works sewage must depend upon the special circumstances of each case. The yard where the coke is cooled should be paved and set to falls, and to drain into trapped gullies. The waste water should be taken into stoneware pipes 6 inches diameter, either to a soak-away or into the main drains of the gas works system.

The best arrangement for the apparatus is to place the retort house and coal store either parallel to each other or end to end. The boilers may be placed next the retort house, the engine in a room next to them, the condensers outside the wall of the retort

house; the scrubber may be placed next, then the washer; neither of these need be under cover. The purifier house should be placed a short distance from the retort house, and away from the boiler fires; this is for the purpose of preventing accidents. The meter house may be near the purifiers, and the gas-holders at any point convenient; a short distance away is not a matter of any moment; it is, however, much more convenient to have them as close as possible to hand, to save labour and trouble of supervision. When the station governor and valves are not placed in the meter house, they may be in a separate room near it; it is very convenient to be able to read the meter and inspect the pressure given by the governor in the supply mains at the same time. The purity of the gas may be tested several times in the day, either in the meter or the governor house.

Retort House.—The first process of manufacture is in the retort house, where the coal is distilled in the retorts. These are set in a bench, and are kept at a cherry red heat by the furnace placed below them. The distillation is gradual. The retorts want very careful setting to ensure they are perfectly and evenly heated. As the gas rises it passes up the ascension pipes placed at one end of the retort to the hydraulic main; the ends of the pipes dip into the tar, and so form a seal, and prevents the escape of gas when the retorts are opened.

The house should be of sufficient size to contain two or three benches of retorts, three in each bench; it may be 25 feet wide by 30 feet long by 20 feet high to the wall plate; the walls 14 inches thick; and the roof, iron trusses covered with slates. An open cupola should run along the top of the roof; the windows should be only on one side of the house, and free ventilation always given. The floor line should be raised 6 inches above the ground line outside; the bottom should be laid in Portland cement concrete about 12 inches thick, covered with blue brick set on edge in cement.

The Benches of Retorts should be two in number, and room left for one spare set. A set of two will occupy a space 14 feet wide by 12 feet deep, 9 feet 9 inches high over all; a space of 6 inches must be left at the side and back, between the benches and the walls, to allow for expansion. The retorts should be of fire-clay, 16 inches diameter by 10 feet long; the size of the benches inside should be 5 feet wide by 5 feet high. The interior of each bench is lined with fire-brick 4½ inches thick; the furnaces to each bench, 12 inches wide by 3 feet 3 inches long, also lined with fire brick. The fire bars should be wrought iron, 2 inches by 2 inches. An ash pan of wrought iron to contain water to keep the bars cool must be placed under the furnace. The retorts have cast-iron mouth-pieces bolted on; these are fitted with hinged lids, cross bars, and screws. The ascension, arch, and dip pipes should be 5 inches

diameter; cleaning doors must be provided at the top of the ascension and dip pipes. The hydraulic main is wrought iron, and is placed on top of the brickwork of the benches; it is 15 inches by 15 inches by $\frac{1}{4}$ inch thick, D shape. A pipe 4 inches diameter, must be provided at one end of the main, at the bottom, to take away the tar and liquor. A 7-inch pipe takes away the gas produced; this is attached direct to a weir valve, which is fixed at the end of the hydraulic main; this keeps the tar in the main at the proper level, and ensures the same amount of dip to all the pipes. The amount of seal given to the dip pipes is adjusted by a screw and graduated scale fitted to the weir valve.

The pipe from the hydraulic main may be carried round the outside of the retort house before it goes into the condenser; this allows the gas to cool gradually.

The benches should stand upon a bed of Portland cement concrete, not less than 18 inches thick. It is very important to keep the brickwork perfectly dry, as well as to ensure that no settlement takes place, which is most disastrous to the retorts and all the joints of the pipes and other apparatus. Six cast-iron clamp girders must be provided, with $1\frac{1}{4}$-inch bolts and nuts at the top and bottom passing through the brickwork of the benches. The retorts taking an average of three years last about 690 days.

The Charge of Coal in each Retort is about 4 cwt. They are drawn every six hours; each of the benches

will carbonise in this time $1\frac{3}{4}$ cwt. to 2 cwt. of coal. Each ton of coal makes 9500 cubic feet of gas, about 12 sacks of coke, 10 gallons of tar, and 14 gallons of ammoniacal liquor of about 14 oz. gravity. The amount of coke used in the furnaces is about 3 sacks per ton of coal carbonised. The coke is drawn out of the retorts into open iron trucks, and is then run out into the open yard to cool. Some portion is left on the retort house floor, and is cooled there by water; this is the portion to be used for the furnaces.

One shaft is sufficient for the furnaces; it need not be more than 30 feet high; it should be lined in fire-brick for the first 20 feet from the main flue. Dampers must be provided in the main flue to shut off any benches when not in use. If the boilers are close to the retort house, the same shaft will serve both boilers and retort furnaces.

Purifying Apparatus, &c.—The gas passes from the retort house through the hydraulic main into 7-inch diameter cast-iron socket pipes to the "condenser," where it is cooled and the tar deposited; it is then drawn by the "exhauster" and driven through the "scrubber," where the ammonia is removed; then through the "washer," where other impurities are taken out; then to the "lime purifiers," where the sulphur, carbonic acid, and other impurities are taken out; it is then passed through the "meter," where the quantity is measured and registered; then to the "gasholders," where it is stored ready

for use. After leaving the gasholders it passes through a "governor" to regulate the pressure, and is then sent out into the mains at a pressure of $\frac{22}{10}$ inch head of water. The weight of the gas holders is made to give the pressure required, subject to the regulation of the governor; the day pressure should not exceed about $\frac{12}{10}$ inch of water. At each apparatus the pressure of the gas passing through is ascertained by water gauges. The gas is pumped from the hydraulic main by an engine and rotary exhauster; the speed and capacity are carefully regulated to induce a flow of the gas, as it is made in the retorts, and to drive it forward through the purifying apparatus to the gasholders. The exhauster is placed *after* the condenser. The gas is carefully tested for impurities; the chief of these are ammonia, sulphur, and carbonic acid. The test papers used are turmeric, acetate of lead, and litmus papers. The illuminating power is tested by a Bunsen's photometer; an argand burner consuming five cubic feet per hour should be equal to sixteen wax candles, each consuming 120 grains of wax per hour.

The above outline is given to render the use of the plant and apparatus clear, each part of which will next be described in detail, as near as possible in the order in which it is used.

Condenser.—The gas is received in this apparatus after leaving the hydraulic main; it is cooled here, and the larger portion of the tar is

removed and deposited in the lower box of the apparatus. The condenser consists of several vertical pipes fixed on a lower box, with inclined pipes to pass the gas from leg to leg. The vertical pipes are made double, leaving an annular space between them; the gas passes through this space nd air passes through the inner pipe; the inlet of which to the internal pipes is regulated by valves. The tar falls from the annular space to the bottom box, from which it overflows through seal boxes to a pipe leading to the tar-well placed underground.

A condenser suitable for the works now described can be made in the following manner:—Two or three 18-inch diameter flanged pipes 18 feet high by ½ inch thick, with a 15-inch diameter internal pipe, are set vertically, and fixed on a cast-iron box about 20 inches wide by 21 inches high and about 5 feet 6 inches long, placed on a foundation nearly level with the ground; the inclined pipes connecting the vertical legs are 8 inches diameter. The fall of the pipe from the hydraulic main to the condenser should not be less than 1 inch in 10 feet; the object is to get rid of as much of the tar as possible before the gas enters the condenser, and in this latter apparatus to cool the gas *slowly* by passing it over large surfaces exposed to the air. This apparatus may also be made with wrought-iron tubes or pipes attached to a cast-iron box as before; as a rule cast-iron pipes are to be preferred. The condenser should be placed next the retort

house wall, out of the sun, if possible, but not too much exposed to cold winds.

Scrubber.—After the gas leaves the last apparatus it passes into the scrubber, which is a cast-iron cylindrical vessel, whose height should be at least three times its diameter. In this vessel the height is more important than the diameter; it is constructed thus:—A cast-iron cylinder 4 feet diameter by 12 feet high, with closed top and bottom; the cylinder is cast with flanges at each end, and to these the top and bottom are bolted. In the inside are two tiers of wood sieves or grids. A manhole is provided at each of the divisions of the scrubber. The inlet and outlet pipes should be 7 inches diameter. The interior is nearly filled with broken bricks or coke placed on each tier of grids. A water distributor is fixed at the top of the scrubber; the gas passes in at the bottom and out of the top, as it finds its way between the particles of coke, the rest of the tar is taken out, if any remains from the last apparatus; and by meeting the water falling from the top, which trickles through the space between the coke, &c., in a fine spray, the ammonia is absorbed. Ammoniacal liquor is thus formed, and falls to the bottom of the vessel, and is taken away through a seal box to the liquor tank or well.

The weight of the apparatus is about 52 cwt.; the bottom is made cup-shape, to allow the tar and

liquor to pass out freely. The inlet pipe must have a cover plate provided, to distribute the gas and prevent it from rushing up at one part only, and also to prevent the falling water from dropping into the pipe. The outlet pipes pass from the top of the scrubber down the side to a pipe underground. A bye-pass pipe and valve are provided to pass the apparatus if desired.

The apparatus should stand upon a brickwork foundation resting on concrete say about 24 inches thick; at the top of the brickwork, stone about 12 inches thick should be provided for the scrubber to rest on; the top of the stone should stand about 15 inches above the ground line; a hollow space in the brickwork is left at the centre for the gas inlet pipe, tar pipe, seal box, &c.

Washer.—The gas after leaving the last vessel enters this one, where, by means of dash plates or other obstructions, the gas is made to meet water in a finely-divided state, and by this means all the rest of the ammonia is absorbed; washers are valuable adjuncts to scrubbers, but should not be used without them. The best kind of apparatus for this purpose is Livesay's patent; the smallest size is sufficient for the present purpose. It should rest upon a brickwork foundation made in the same manner as for the last apparatus. The pipes, inlet and outlet, may be 7 inches diameter. The ammoniacal liquor may be taken away by a 3-inch diameter pipe to the well

or tank. A bye-pass pipe and valve are also provided at this apparatus, to allow the gas to pass outside it when it is under repair.

Purifier.—After leaving the "washer" the gas passes through this vessel; it is charged with lime, and by this means all the sulphur, carbonic acid, and other small impurities are removed. Oxide of iron is sometimes used instead of lime. One advantage of this means of purifying is, that after the material is foul it can be revivified and used again. When however, the spent lime can be got rid of on to the land, it is the preferable material to use, added to which it more perfectly purifies the gas.

The construction of the purifiers is as follows:—Cast-iron plates, 3 feet 6 inches wide, with flanges, are bolted together and formed into a box, with plates at the bottom, also flanged and bolted together. At the top of the side and end plates a water lute 18 inches deep is formed; into this a wrought-iron cover dips, and is secured by hinges and bolts to the sides of the water lute. The inside is provided with three sets of wood sieves, on which lime is placed in an even layer about 9 inches thick. A pipe is provided at the bottom of the purifier for the inlet of gas; and at one corner of each purifier an outlet box is fixed from the top to the bottom of the vessel the gas is driven through the lime and passes to the top and then down the outlet chamber to the bottom, where it is received in the outlet main.

Two purifiers, 7 feet by 7 feet by 3 feet deep, are necessary in the present case. The weight of cast iron is 36 cwt., and wrought iron 5 cwt. The plates are ½ inch thick; there are three tiers of wood sieves in each. The covers are of wrought iron plates $\frac{3}{16}$ inch thick, curved at the top, riveted together with butt joints and cover plates, an L iron ring runs all round the cover to which the side sheets ¼ inch thick are riveted. An L iron ring also runs all round the bottom of the side sheets to strengthen them. Two eyes for lifting the covers should be fixed at each side of it. Chain slings are attached to each of the eyes, thus forming two points at which the cover is lifted.

The purifiers should rest upon brickwork walls, with a space underneath to get at the pipes, &c.; they should be placed in a house alone; the roof may be iron, close boarded and slated; ample ventilation should be provided at the top; no open light should be allowed in the room; gas lamps may be sunk in the wall, but hermetically sealed from the room. The inlet pipes are placed at one side of the purifiers, and the outlet pipes at the other, with valves attached, so arranged that either or both of the purifiers may be worked as desired; bye-pass pipes and valves are also provided, and a syphon box to take all liquor and other deposit. The gas when leaving the purifiers should be as dry as possible.

A Traveller is requisite to lift the covers Many

suitable forms of these machines are made by Messrs. G. Waller & Co., London; they may either be constructed to run on a timber gantry, or made in the form of a "Goliath," and run on wheels upon rails on the floor of the house; the traveller should be capable of lifting 10 cwt.

Meter.—The gas passes through this machine to be measured; it must be placed in a separate room by itself, except that the station governor may be placed there also when it is convenient. The size of meter required is 5 feet 2 inches diameter by 4 feet 9 inches long. The meter should rest upon brickwork; the connections should be 7 inches diameter as before. A clock indicator records the gas as it passes through, and also marks upon a circular card the amount passed each hour. Messrs. A. Wright & Co., and Messrs. Parkinson & Co., are makers of these apparatus.

The room may be made 10 feet by 10 feet, or 12 feet by 12 feet, by 9 feet high to the wall plate; a small portion may be divided off by a wood partition for a photometer room; the interior of this must be dark, and the walls and ceiling painted black; a table about 2 feet 6 inches wide by 8 feet long must be provided here; the fittings necessary for the room are a Bunsen photometer, meter, jet photometer, &c.

A standard cubic foot of gas is taken, at a pressure of 3 inches of water, to measure $6\frac{1}{4}$ imperial gallons

and to weigh 214 grains. The expansion of gas for every degree of heat is 1 in 480.

Station Governor.—This may be placed, as before stated, in the meter house, or it may be in a small separate room. All the gas going into the mains after it leaves the gasholder passes through this apparatus for the purpose of regulating the pressure. A record is kept in this room to show the pressure of the gas sent out into the mains at every part of the day and night. This apparatus is automatic, and cannot be interfered with by the attendant. The firms above named who make meters also make these apparatus, as well as the sundry fittings required in the room. Parkinson's is one of the best governors to use.

Gasholders.—After the gas leaves the meter it passes into the gasholders, where it is stored; the capacity of these must be equal to the supply required for 24 to 36 hours at least. Two should be provided; they may each be 30 feet diameter by 15 feet deep single lift. The water tank should be of brickwork, built in Portland cement, with a backing of cement concrete; the top of the walls should have a stone coping 6 inches thick, the bottom should be concreted, the thickness of this will depend upon the nature of the soil; it may be paved with bricks set in cement. In some instances a cone of earth may be left in the centre, and on this a brick pier is built, on which the holder rests when down.

Six guide bars are fixed to the side walls of the tank in the same position as the upper guide bars that are fixed to the columns.

The holder is made of wrought-iron sheets, No. 14 B.W.G.; it should have six inside stays of T iron, and be trussed in the crown; six guide rollers are fixed to the top of the holder, and six to the bottom curb; and opposite these stays six cast-iron columns 7 inches diameter by $\frac{5}{8}$ inch thick, are bolted to the tank walls; guide bars are fixed on the front of each column to guide the holder as it rises and falls. The tops of these columns are connected by wrought-iron girders about 15 inches deep, of the trellis form. The inlet and outlet pipes are 7 inches diameter. The average pressure of the holder is $4\frac{1}{2}$ inches head of water.

An outer dry well is formed close to the tank, and in this the inlet and outlet pipes pass down under part of the bottom of the tank and up above the top level of the water.

The details of these apparatus differ to suit certain circumstances. In some cases, when the ground is bad, the tank is made of cast iron, in much the same manner as a water tank; in this case it is sometimes partly sunk in the ground and in others the bottom stands upon a concrete foundation at about the level of the ground line.

Engine, Boilers, and Exhauster.—To exhaust the gas from the hydraulic main and drive it through

the purifying apparatus, a rotary exhauster is necessary. This is driven by an engine, the steam being supplied from a boiler fixed near to it. The engine and exhauster are worked combined, and are fixed upon one bed plate. The boilers and engines will be separately described.

Boilers.—For supplying steam for the engine for exhausting the gas and pumping tar, liquor, and water for the works, two boilers (one a duplicate) should be provided, 3 feet diameter by 9 feet long, with a steam chest 18 inches diameter and 18 inches high; they should be cylindrical, with the ends dished; they must be set in brickwork side by side. The fuel used is breeze, or small coke. Boilers of this kind are the most suitable for gas-work purposes on a small scale, as they want but little attention, and are perfectly safe in unskilled hands. They should be fired with breeze from the coke, which is usually of little value; the furnaces should be made large, and adequate air space given between the fire bars.

The house for the boilers should be separate, and placed next the engine room; the walls 14 inches thick and about 14 feet high from the floor line to the wall plate; the roof may have iron trusses, and be covered with boards and slates; the size of the room about 14 feet wide by 21 feet deep; this allows about 8 feet in front of the boilers for stoking. The floor of the house may be covered with Stuart's patent granolithic concrete, and in front of the

boilers a wrought-iron plate 4 feet wide should be placed, on which the fire is drawn out when required.

The fittings for each of the boilers are, one $2\frac{1}{2}$-inch diameter safety valve, one 2-inch stop valve, one 1-inch diameter feed valve; one $1\frac{1}{2}$-inch blow-off cock; cast-iron furnace doors and frames, a set of soot-doors and frames, a steam-feed pump and pressure gauge, two dampers and frames, chains, and counterbalance weights, also a full set of stoking tools.

Engine and Exhauster.—This is for exhausting the gas from the hydraulic main; the best kind are those made by Messrs. G. Waller & Co., in this case say equal to 2000 cubic feet per hour. The engine and exhauster are combined on one bed plate, the size of which is about 2 feet 6 inches by 2 feet 6 inches; the speed of the exhauster is about 150 revolutions per minute. The inlet and outlet pipes are 5 inches diameter; a bye-pass valve is fitted in the pipes to open in case of any obstruction; this is situated upon a cross pipe between the inlet and outlet pipes; in addition to this a small cross pipe 3 inches diameter is fitted and placed parallel to the last-named pipe; this has a throttle valve fitted in, which is controlled by a hydraulic governor. If the exhauster is running too fast it draws down the bell of the governor, and by means of levers opens the throttle valve, and the gas is pumped round again until an equilibrium is obtained. A steam governor is also placed near the engine, and is geared to the throttle valve on the

steam pipe; it is a bell hydraulic governor, but constructed in a different way to the last; by this apparatus the speed of the engine is controlled to suit the varying make of the gas; when properly adjusted the gauge in the inlet to the exhauster will not vary $\frac{2}{10}$ths of an inch of water.

Pressure gauges are placed in this room showing the suction on the hydraulic main and retorts, also the pressure from the different purifying apparatus. The room may be constructed in the same way as the boiler room, and in size 10 feet by 10 feet by 14 feet high to the wall plate; there should not be any direct connection between the Engine room and Boiler house.

Pumps for Water and Tar may be of the direct-acting steam type; they are not the most economical for use in larger gas works, but are suitable in works of the size now under discussion.

Nearly all the above-named apparatus can be obtained of Messrs. G. Waller & Co., London, who also undertake the entire fitting up of gas works.

Mains.—The main supply pipe should be 6 inches diameter; the weight of a 6-inch socket pipe 9 feet long is 2 cwt. 1 qr. 14 lb.; they should be jointed with tarred yarn run with lead and caulked. Each joint will take about 6½ lb. to 7 lb. of lead. The cross pipes for branch services may be 4 inches diameter, and 3 inches diameter for minor services. A 4-inch diameter pipe weighs 1 cwt. 1 qr. 14 lb.,

and a 3-inch diameter pipe 3 qr. 14 lb.; the quantity of lead for a 4-inch joint is $4\frac{1}{2}$ lb., and $2\frac{3}{4}$ lb. for a 3-inch joint. All junctions must be made with curved pipes. T pieces must be avoided wherever possible; no sharp corners must be left anywhere, nor must the pipes in the trench be dipped at any part. In places where one pipe must cross another a "rider" must be put on. The following are the weights of sundry connections: a 4-inch syphon 2 cwt., a 6-inch $4\frac{1}{4}$ cwt., a 3-inch diameter bend 1 qr. 11 lb., a 4-inch diameter 2 qr. 4 lb, a 3-inch T piece 2 qr. 20 lb., and a 4-inch 3 qr. 21 lb.

Valves must be provided to shut off any section of the mains, and at each section of the house or main building an extra governor should be provided to adjust the gas pressure as required. It should be borne in mind that small mains should never be used for gas, as it is necessary to pass it through them with as little friction as possible.

Syphons must be placed at intervals in the mains to keep them free from water, naphthaline, and other deposits. The mains should be placed at least 2 feet 6 inches to 3 feet under the ground, to keep them free from frost and from injury from passing loads. At intervals small pipes and cocks must be provided in the mains, to take pressures at any part, and so be able to locate any stoppage; over each of these pipes and cocks a top box must be placed level with the ground. The velocity of the gas through the main is about $1\frac{1}{2}$ miles per hour. The cost of

cast-iron mains laid in trenches, taking the metal at 6*l.* per ton, is: for 3 inches diameter, 2*s.* 5*d.*; 4 inches, 3*s.* 10*d.*; 6 inches, 6*s.*; 7 inches, 7*s.* 6*d.* per yard.

Coal.—Where there is water carriage the coal may be wheeled direct into the retort house or coal stores from the barge, or it may be put into small wrought-iron trucks and run on rails into them. When large quantities have to be unloaded, it may be convenient to adopt steam or hydraulic cranes or lifts; it is not, however, usually necessary in works of the size under consideration.

Stores for coal should be provided to hold at least two weeks' supply; they need only be covered sheds with walls at the side carried part way up; the roof may be supported on cast-iron columns. It is necessary to keep the coal dry; when a little extra expense is not a consideration, the stores should be closed in; very little light is necessary. The coal should not be stored a greater depth than can be avoided, as it deteriorates very much when this is done. For every ton of coal provide 42 cubic feet of space, and allow for trimming.

Tanks.—These must be provided for tar and liquor, and may be placed underground if desired, or the tar, &c., may be received in a small tank underground and pumped up into cast-iron tanks placed above ground; they are usually made circular for these works, say 4 feet diameter by 10 feet high; taps

should be fitted at different levels to draw off any required density of liquid, the lowest one being placed rather above the level of a barrel contained in a cart ; the tar should flow in through a valve, to which a canvas hose is attached, and pass direct into the bung hole of the cask.

The cost of construction of a Gas Works of the size above described, assuming that bricks and all materials, as well as the carriage of goods, can be obtained cheaply, will be about 2500*l.* to 3000*l.* The cost of the foundations and the construction of the gasholder tanks affect the cost considerably, and vary according to the nature of the soil ; the above figures are, however, safe to take for average cases.

The works must be kept in action twelve hours per day, the retorts being slackened down at night. Two men, or a man and a boy, will work the place.

The particulars here given will be sufficient for an architect to specify what he wants for a small work ; in large cases it will be advisable to seek the advice of a consulting engineer experienced in this branch of practice. Anyone requiring any more details of plant or buildings is referred to the author's book upon 'Gas Works,' E. & F. Spon, London, where all parts are considered in detail, both for small and large works. The construction of gasholders is treated in full detail for all sizes ; the tanks are also described. Several arrangements necessary for

public gas works are not necessary in this case, and so have not been described.

Gas Lighting outside the Works.—The grounds and all exterior parts are lighted by ordinary cast-iron lamp posts and brackets. The posts weigh 3 cwt. 1 qr. each, and, fitted complete with lantern, are worth 2*l.* 15*s.* The consumption of gas averages for each light about 20,000 cubic feet per year.

Wrought-iron brackets for fixing to walls are about 10*s.* each, the lanterns 9*s.* each, connections, with fittings and fixing, 15*s.* It is usual to fit some of the lamp posts with meters; the average consumption of all the lamps is taken from the average reading of the meters. In this way the cost of each section of the out-door lighting can be kept separate.

House Lighting.—Large asylums are often built in separate blocks. In cases of this kind a 3-inch or 4-inch branch may be brought from the main pipe by a Y or curved connection to a meter, which should be placed in a cool room, and at the lowest part of the building. The main inlet and outlet pipe to the meter need not be more than 3 inches diameter; they should be cast-iron socket pipes jointed with tarred yarn and run with lead. The main outlet from the meter, 3 inches diameter, feeds all the cross pipes to the various rooms. After the greatest part has been taken off it may be reduced to 2 inches and 1½ inch diameter; these should be wrought-iron pipes. The service pipes for the rooms,

corridors, &c., must be put together with connecting pieces at every 10 feet to 12 feet, to permit easy removal of the pipes for cleaning and alterations; the main services should be $1\frac{1}{4}$ inch diameter, and the smaller ones 1 inch and $\frac{3}{4}$ inch. No connections to the gas brackets should be less than $\frac{3}{8}$ inch diameter; all pipes should be iron, composition pipes must never be used. The pipe connections must not be sunk in the wall or plaster, and in most cases it is preferable to carry the pipes across the ceilings and not sink them into the floors above the ceilings, as is usually done. Bends should be used where possible; and if elbows cannot be avoided, only the round shape should be used. At all cross connections cleaning caps must be provided. Instead of using T pieces, crosses may be substituted, a plug screwed in opposite the cross service pipe forms the cleaning cap. At suitable points in the service pipes, drain cocks must be provided to keep the pipes clear of water and deposit. All cocks in the mains should be iron; each should have a spanner pinned on, and be placed where it cannot be interfered with. Each meter should have a small governor attached to regulate the pressure. The cost of fitting up the gas pipes and ordinary barrel brackets and pendants, with cocks and all connections, exclusive of meter, main cock, and governor, may be taken at 18*s*. to 20*s*. per burner; in the officers' departments, chapel, &c., the extra cost per burner between single lights of ordinary barrel and the cost of the brackets and

gasaliers put in must be added. This figure is given as approximate for the purpose of forming estimates; it may, however, be taken as a safe figure for work of this class.

Gas Brackets, &c.—The wards should be lighted with fixed brackets or pendants, and in some of them the lights must be absolutely enclosed. For large rooms, sun burners by Messrs. Strode & Co. may be adopted. These lights are very suitable for the chapel, entertainment room, or other large meeting places; for smaller rooms the Cromartie lights by Messrs. Sugg & Co. are very good. Dining halls may also be lighted with these lamps. The water closets, &c., should be lighted by lamps placed outside the walls, or, when several closets are placed together, with dwarf partitions between them, a closed lamp may be placed high up above reach.

At the kitchens or any part where gas is required for cooking or heating, the pipe connections must be of ample size to give a good supply. Gas fires may be used to temporarily heat rooms, &c., that are only occasionally used, and are too far from the hot water heating apparatus. Perfect ventilation must be provided to carry away the products of combustion. Where only a gentle heat is required, "George's Patent Calorigen" may be used; the gas in these is hermetically sealed from the room. The air to supply the burners and the products of combustion are taken in and discharged through the outer

wall; the cold air is also taken in through the outer wall.

In many cases a sufficient sum is not allowed by architects in their specifications for providing and fixing the gas pipes and their fittings. This may possibly account for some of the indifferent work that occurs at times. In this department of work the same remarks apply as those made at p. 18. The efficient execution of gas pipes and fittings is of the greatest importance to the comfort and health of the inmates, as well as saving of trouble to those who have to work the institution.

Ventilation.—The rooms where gas is used must be well ventilated; openings must be left in the ceilings of the rooms and passages, and in connection with these zinc tubes must be carried to the outer air; and must be so constructed at the outlet that back currents of air are prevented. Fresh air should be brought into the rooms, passages, and staircases by Tobin's tubes at about 5 feet high from the floor line; whenever possible the inlet of air for these tubes should be in direct connection with the outer air, and not taken from any corridor or passage. The heated air from the gas burners passes away at the top of the room, and fresh air takes its place; the amount of this can be regulated. To ventilate large rooms when the gas is not lighted, a small jet of gas may be burned at each of the outlets in the ceiling; a very small amount of gas is required; it creates a

current, and causes the foul and heated air to ascend and pass out. When the rooms or wards are next an outer wall, Sherringham's ventilators may be placed near the ceiling; in some cases Arnott's are preferred, as they only open outwards, and so back currents of air are prevented.

The corridors, passages, and staircases should be ventilated in the same manner, and in addition to this a large Boyle's ventilator should be placed at the top of each staircase. Air-shafts must be provided to ventilate all central rooms, &c., not in direct contact with an outer wall. The lower part of the shaft must be heated slightly by gas or any convenient means to create a suction to draw out the hot air at the outlets from the rooms, as described above. Large cowls or ventilators must be fitted to the top of these shafts; the size of the shaft must be proportioned to the capacity of the rooms, &c. to be ventilated.

Over each of the gas brackets in the corridors and passages, a tube coned at the bottom, with the outlet connected with the outer air should be provided, either carried through the wall or the roof, as may be most convenient. A Boyle's ventilator cowl may be fixed on top of each; the products of combustion of the gas and all the hot air will be effectually removed by this means. Every room and place where gas is burned requires efficient ventilation; when properly carried out no draught is created. The object is to effect a constant change of the air. The

heat of the rooms must be regulated by the warming apparatus.

The subject of general ventilation has also been treated in Chapter V., at p. 66. When this is carried out, some part of the above work may be dispensed with.

CHAPTER XII.

BREWERY.

In institutions for adults of 600 inmates and above, a brewery is usually provided. Taking a place for 1000 inmates as an example, a 5 to 6 quarter plant will be sufficient. The site of the brewery should, if possible, be on high ground, and free from buildings, especially any place such as the gas, sewage, or other works, where the air might be contaminated. The next most important thing is to obtain water suitable for brewing purposes: it must be borne in mind, water may be good for drinking, but useless for brewing; if the water from the well supplying the place cannot be used, a trial hole should be sunk elsewhere to determine if water of the requisite quality can be obtained. Should it be shown that no suitable water can be procured on the spot or from any outside source, the brewery must not be erected. Assuming that good water for the purpose can be procured, and in abundant quantity, the following is a description of a suitable construction that should be carried out.

The Brewery should be erected for a 5 quarter plant with room for its extension when required. The building is constructed in brickwork, with

stages and floors to carry the various utensils and plant as required. The tun and cooler rooms should have a north aspect, and the cellars must be placed in a cool position. If the site is on sloping ground, it can be very advantageously used, the plant in this case can be so arranged that all the various vessels command each other. The means of receiving and taking away materials and goods must also have consideration; good foundations are a necessity, as the plant and vessels to be carried are heavy. The plant must nearly all work by gravitation; only one pumping up is required; this is after the wort is boiled, and in the hop back, it is then pumped to the coolers, and again gravitates to the bottom. By this arrangement, the copper and hop back being placed on the ground floor, much expense is saved; and all vapour kept out of the brewhouse; the copper and hop back should be placed in a separate building with a lofty roof, and have free top as well as side ventilation. The boilers may either be placed in the copper house, or in an adjoining separate place. The mash tun must be conveniently situated to dispose of the spent grains. The hop and malt stores should be at the top of the building, in a room quite free from steam and vapour; very little light is wanted; the roof of the building must be close boarded, and covered with felt and slates—it is advisable to plaster the underside of the roof rafters. If malt is stored in bins, they should be made deep, as in this way it keeps better. The roof

over the cooler room, when it is on the top floor of this section of the building, should be finished in the same manner as described for the hop and malt stores. All parts of the building must have free ventilation except the stores above named. The part of the stores where the hops are kept should not have too much light; wood shutters should be provided inside the building at this part.

Drainage must have careful attention; large quantities of water are used in a brewery for cleaning the vessels and the floors, &c., and in consequence much waste water has to be disposed of; it must be carried outside the building, and be discharged over trapped gullies, which must be perfectly disconnected from the main drains or sewers. When any drain pipes must be laid under any part of the brewery, they must be cast-iron socket pipes, and be jointed with tarred yarn and caulked with lead; except for short cross pipes from the centre of the rooms to the outside, these internal drain pipes can nearly always be avoided in small breweries like the one now under consideration. The flooring of the cellar may be Stuart's granolithic concrete; the ground floor should be "Claridge's Patent Seyssell Asphalte," laid upon a bed of fine Portland cement concrete. The cellar may be arched over with Dennett's patent arching, or arches of Portland cement concrete may be used; the fine concrete and asphalte are laid direct on top of the arches. One very great advantage of asphalte is, it is impervious to moisture, it presents a perfectly

smooth surface, and is easily kept clean. The concrete for these floors must be carefully made at the bottom with stones that will pass through a $1\frac{1}{2}$ to 2 inch ring, and finished finer towards the top part.

The floors and plant should be supported upon cast-iron columns, and wrought-iron girders; in the brewhouse or mash-tun department closed floors are seldom necessary, instead of which stages are provided at the requisite level for each utensil; the columns and girders are so arranged to take all the plant requiring support in this part of the place. At the top of this building an open glazed lantern should be provided, fitted with swing sashes. The windows must be placed to suit the plant inside; where light and ventilation are required, they should be fitted with swing sashes made in sections, and operated from the floors by simultaneous opening and closing gear. The staircases may be iron, also the floor or stage of the mash tun, &c., when wood is not preferred. The refrigerator room must be placed well exposed to the wind, and if possible out of the sun; wood louvres, each set being worked by simultaneous opening and closing gear, must be provided at the sides of this part of the building, and, if open to the roof, a cupola fitted with louvre boards should also be provided.

The first thing to be done in designing a brewery is to decide the size of each part of the plant. It

should be remembered the place is usually divided into three departments: 1, the brewing house; 2, copper house; 3, fermenting department.

The brewhouse department is the highest part of the building; it contains, beginning at the top, cold liquor-back, hot liquor-back, grist case, mash tun, underback; also, in a part divided off, malt hopper, malt rolls, and screen. To ascertain the necessary height and the size of this part of the building, the designer must commence at the ground floor of the copper house. The ground floor, under the mash tun department, is usually raised about 3 feet above the ground line outside, to facilitate the loading of the beer on to the drays or carts; the casks can be rolled direct from the floor on to the level of the drays, etc.

Commence with the hop back in the copper house, the floor of which may be 6 inches above the ground line outside, place the back 1 foot 6 inches above the floor to the bottom; then set out the copper cock, the depth of the wort boiling copper, and commence in the brewhouse department with the underback, and place the bottom, say 9 inches above the top of the copper; the space between this and the underside of mash tun should be about 9 inches; the space between the top of mash tun, and the bottom of the grist case, must be sufficient to allow a proper fall to the exterior Steel's mashing machine. The grist case is placed over the mash tun, the bottom of the hot liquor back at least 6

feet to 7 feet above the Steel's machine, and the cold liquor back bottom 6 inches to 9 inches above the top of hot liquor back. Let the sides of the cold liquor back clear the underside of the roof, and leave headway for cleaning out the interior, thus the height of the roof is ascertained.

Fermenting Department.—Commence at the ground floor, which is placed 3 feet above the exterior ground line, and place the bottom of the racking back 3 feet above the floor, then the yeast back about 4 feet above it, then the bottom of the tuns about 4 feet above the yeast back; the refrigerator pan 12 inches above the top of the tuns, and the cooler about 12 inches above the top of the refrigerator. Leave a headway of 6 feet 6 inches above the cooler bottom to the tie beams of the roof, and a gangway, 3 feet wide, round one side and one end of the cooler.

It will thus be seen, the process in the brewhouse gravitates from the cold liquor back at the top of this part of the building to the copper house at the bottom; and after the beer is pumped up from the copper house, it gravitates from the cooler at the top of the fermenting department to the racking room or ground floor, where it is run into the casks ready for storing in the cellar.

The inside of the building and plant must be designed first, the floors and stages put in to suit the utensils. The windows must then be placed where

they will give light and ventilation, and of a suitable size and shape for their purpose. The front of the building must be made to suit the internal requirements; the doors and stairs must be arranged to give easy and quick access between the different parts of the plant, and for getting in and out all materials. If any windows of the fermenting room face south or west, they must be protected from the sun by outside blinds.

The process carried on in the brewery, if understood, will make it easier to set out the work; an outline is therefore given to assist the architect. Most of the technical brewing details have been omitted.

Cold liquor or water is let down from the cold liquor back into the hot liquor back, where it is boiled, and let down to the mash tun as required. The malt having been ground in the mill and put into the grist case placed over the mash tun, is let down into a Steel's patent mashing machine, where it meets the hot liquor from the back; the mashing then takes place, and the goods sent out into the mash tun, where they remain for about two hours; the sparger is set to work to sprinkle hot liquor on top of the goods. At the proper period the wort is drawn off from the bottom of the mash tun into the underback and let down when ready into the copper, where it is boiled for two to three hours, the hops being added at a certain stage of the process; when completed it is let out into the hop back, where the

boiled wort is strained from the hops. The wort has now gravitated to the ground floor; after resting a short time in the hop back it is pumped up on to the coolers, which are situated on the top floor of the fermenting department, where it is cooled. After remaining in the coolers for about one hour, the wort is run off on to the refrigerator, from thence to the fermenting tuns, where it is fermented, yeast being added at this stage to start the fermentation. The yeast as it rises is skimmed off the top of the beer in the tuns into a slate back, and the finished beer is let down into the racking back placed on the ground floor, from which the casks are filled, and made ready for the store cellar.

As there are two systems of gravitation, it will be seen that great care must be used in having proper head room, and also in disposing of the floors and stages so that the process may be properly carried out.

To remove any chance of error, as each apparatus is described its purpose will be again indicated; this may cause a little repetition, but to make the matter clear cannot be well avoided. A list of the plant necessary for a brewery of this size will now be given, after which it will be described, and the requisite dimensions given in full detail. Some modifications may be requisite to suit special cases; they are not, however, material, and will not interfere with the general design of the brewery. With regard to the materials of which the brewing vessels

should be made, some difference of opinion exists, especially as to the fermenting tuns. They are in some instances made of slate, but more generally of fir; they are rather more expensive when made of slate, but present many advantages which in the opinion of many outweigh their slight disadvantages. The plant now about to be described is suitable for the case under consideration, and is designed with a view to economical construction and for permanent use without much wear and tear.

The Plant will consist of:—

One cold liquor (or water) back One hot liquor back .. .. One mash tun .. .. One grist case .. .. One underback	placed in the brewhouse department.
One copper for boiling wort One hop back	placed in the copper house.
One cooler .. .. .. Three fermenting tuns .. One refrigerator .. .. One yeast back .. .. One racking ditto	placed in the fermenting department.
One boiler .. .. .. One engine	in separate houses.
One set of pumps	in copper house.
One yeast press and one hop press	in racking room.

One sack hoist gear. .. .. One pair of malt rolls and screen .. .. .. One malt hopper	in the grinding department.

The plant will now be described in nearly the same order in which it is used, its purpose will also be indicated. This plant is laid out upon the skimming system, which is very suitable for asylums, &c.

Cold Liquor Back.—This is made of cast iron, put together in plates and secured by bolts; it is made and fitted up in the same manner as the water tanks described at p. 43. The size is 12 feet 6 inches by 6 feet by 4 feet deep, and ½ inch thick, the contents equals 50 barrels. It is placed at the highest part of the building to command all the apparatus. The back will weigh about 5 cwt.; it must be supported at each joint by wrought-iron girders resting at one end on the wall, and at the other on a girder placed across the house and built into the main walls. The rising main from the pumps, 3 inches diameter, delivers over the top of the back. A hollow trumpet-mouthed overflow pipe is provided at one corner, fitted with a gun-metal plug and bush. The supply to the brewery is taken from the bottom of the back; the pipe is raised 3 inches above the bottom to keep out the sediment; a perforated rose of free area covers the top of the pipe. The back may be lined with glazed bricks set in cement; this is a good plan, and

does not cost much; it must, however, be considered in dealing with the weight to be carried. An allowance of 5 cwt. per barrel of contents is sufficient to cover the total weight (this is exclusive of glazed brick lining). The backs must always be placed *under* the roof, and sufficient room left for men to get in and clean out; be careful also to see that there is sufficient light.

Backs of this size and depth cost about 18*s.* per barrel of contents; this does not include the girders, pipes, or fittings. The down main passes in a convenient position to the bottom of the building to allow a supply to be taken off T pieces which must be provided in it as required. The pipe to supply the hot liquor back, which is placed under it, is usually made separate; this allows the back to be filled quickly and independently of the general supply.

Hot Liquor Back.—The top of this is placed about 6 inches to 9 inches below the bottom of the cold liquor back, it is made of wrought iron $\frac{3}{8}$ inch thick; the size is 8 feet 6 inches by 5 feet by 4 feet 6 inches deep, the contents equals 30 barrels. The back is made closed at the top, and is fitted with a steam copper coil, 2 inches diameter, to boil the liquor; the length is 90 feet; the steam pipe and cock is 2 inches diameter; the down pipe to supply the various apparatus is 3 inches diameter to the mash tun, and is made of copper $2\frac{1}{2}$ lb. per foot; it may be reduced to 2 inches after the supply to the

boiling copper is taken off. A manhole frame fitted with a steam-tight cover is provided at the top of the back to get in and clean out when necessary. All of the outside of the back must be covered with non-conducting composition, and lagged with wood staves, bound on by iron hoops. The value of this vessel is 35*l.*, and the coil, &c., about 90*l.*

Mash Tun.—This should be placed under the grist case, and at least 6 to 8 feet below the hot liquor back; a head of water not less than this is necessary for the exterior Steel's mashing machine. The mash tun is made of oak staves, 3 inches thick and 6 feet 4 inches in diameter, by 4 feet deep inside; it will hold 20 barrels. A Steel's mashing machine is provided, and is placed on the outside of the tun, and driven by the shafting at a speed of 300 revolutions per minute. A cast-iron false bottom well perforated with fine holes is placed 2 inches above the bottom of the tun; it stands upon feet in the centre, and on a wood curb running all round the tun. A copper sparger must also be provided: it works upon a pin and cross bar fixed at the top of the tun. A supply pipe from the hot liquor main must be carried to the sparger, and be fitted with a bibcock.

A wood cover hinged at each side of the centre is also necessary. At the bottom of the tun three 1½ inch diameter draw-off cocks and copper pipes are fitted; these pipes are carried to the underback, and

have bibcocks fitted at the end to draw off the worts when ready. These pipes are attached to the cocks by unions, and made capable of easy removal for cleansing.

It is important to keep the tun and the goods hot during mashing time. A grains-valve is fixed at the bottom of the tun to drop out the grains when the brewing is over. A pipe or shoot with a hopper head is placed under the valve, and is taken outside the building to deliver direct into carts. The bottom of the mash tun rests upon wood joists 4 inches by 4½ inches at 2 feet 6 inches centres, these again resting upon wrought-iron girders. The chime of the tun must not rest upon any of the bearers.

Underback.—The top of this vessel is placed about 12 inches below the mash tun; it receives the wort from it. It is made of copper 6 lb. per superficial foot, the size is 5 feet by 3 feet by 2 feet deep, the contents equals five barrels. This vessel is not intended to take all the wort. A steam coil made of copper must be provided to keep the wort hot; this is 1½ inch diameter, and made of copper 4 lb. per superficial foot. A cock must be provided to regulate the supply of steam, and a condense box to keep the coil free from water. An outlet copper pipe, 3 inches diameter, is attached to the bottom of the back, and a screw down valve on the inside. The wort is run off into the copper through it.

Copper.—This is placed just under the pipe from the underback; the wort is boiled in it; it is made of copper plate; the size is 5 feet 6 inches diameter by 6 feet deep; the bottom is made concave, and an average of $\frac{3}{8}$ inch to $\frac{7}{16}$ inch thick; the sides to the safing are $\frac{1}{4}$ inch thick, and the light or upper course $\frac{1}{8}$ inch to $\frac{3}{16}$ inch thick. At the top of the upper course a $2\frac{1}{2}$-inch L iron is riveted; the copper sheet is turned over it. Two wrought-iron bands are fitted to the upper part of the copper. The nett contents is 21 barrels; it will boil 16 barrels of wort; about one-quarter is always allowed for expansion of the wort when boiling. An outlet pipe and cock, 4 inches diameter, is fitted at the bottom, and placed at an angle to entirely drain the copper. The copper is set in brickwork, and is heated by a furnace placed under the bottom and by side flues passing round the lower part. The flue may be connected to the boiler shaft. Wrought-iron bands are provided outside the brickwork to secure it. Proper dampers, chains, and weights must also be provided.

The weight of this copper is about $11\frac{3}{4}$ to 12 cwt., exclusive of the iron work. The allowance made in coppers is from $3\frac{1}{2}$ to 4 barrels per quarter of malt brewed. It is a handy thing to remember that every $\frac{1}{16}$ inch of thickness of copper equals 3 lbs. per superficial foot. The average value of a copper of this size is about 80*l.*; this price will, however, vary with the price of copper. As a rough rule, about 4*l.* per barrel of nett contents is suffi-

ciently near for most purposes for forming estimates; this is exclusive of the brickwork and iron bands.

Hop-back.—This vessel is placed under the copper cock, or pipe, and receives the wort after it is boiled; it is 9 feet by 5 feet by 3 feet deep, and holds 20 barrels; it is made of fir 3 inches thick, and is fitted with a cast iron perforated false bottom; this is placed about 4 inches above the bottom of the back; the hops are kept on the top of the false bottom, and the wort runs through it, and is raised by the pumps to the coolers. A pipe is carried from the space under the false bottom to the top of the back, to carry away the air and vapour. The bottom of the back is placed rather above the suction valves of the pumps, to keep them well charged; the wort is almost boiling when it leaves the hop back. The pipe connection at the bottom of the back is 3 inches diameter, copper $2\frac{3}{4}$ lb. per super foot. A screw-down valve is placed inside the vessel, and a rod is carried to the top of it. A valve of the same description is fixed near it for washing out; a cast-iron pipe 3 inches diameter takes away the waste water; it must not be connected direct to the bottom of the back, but be received in an open waste box; this is for the purpose of detecting any leakage of wort should the valve not be quite tight.

The value of hop backs of this kind is about 12*s.* per barrel of contents, and the false bottom 4*s.* per super foot. The back should be placed about 12

inches to 18 inches clear of the floor line, which is usually the ground floor of the building.

Pumps.—The suction-valves of the pumps are placed below the bottom of the hop back; the wort is pumped up by these to the coolers, which are placed upon an upper floor; a set of three-throw pumps set in a cast-iron frame should be provided, the barrels 3 inches diameter by 12 inches stroke, and be driven at a speed of 30 revolutions per minute at the crank shaft. The pipes leading to and from the pump must be 3 inches diameter, made of copper, and tinned inside and outside. The crank shaft of the pumps is driven from the shafting by a leather band; fast and loose pulleys are provided to throw in and out of gear as required. The delivery or rising main is carried over the top of the coolers; a large copper air vessel must be provided and placed near the delivery valves. The quantity pumped per hour is 50 barrels.

Cooler.—This is made of fir, and is placed in an upper part of the building over the fermenting tuns; the level must be determined by setting out this part of the place, starting at the ground floor with the racking back, with the tuns above, the refrigerator above the tuns, and the coolers on the top; about 12 inches between the top and bottom of each apparatus is required, except at the tuns, where more head room is wanted. The beer is pumped up from the hop back to the coolers and exposed to the air; the depth of the wort should not be more than 4 inches to

6 inches at the maximum; the size inside is 18 feet by 11 feet 6 inches by 7 inches deep, 3 inches thick at the sides, and 2 inches at the bottom; the cooler will hold 16 to 17 barrels. It is placed upon under-ribs of fir, to which the bottom is spiked; these rest upon girders of wrought iron, the main ones run across the building, and rest upon the side walls. The outlet for the wort is a screwed valve and seat placed at one end of the cooler; the cooler is set with a fall of about 2 inches in 10 feet to this end; a waste plug and valve is also fitted at this end for washing out after the wort is run off; the waste water runs into an open box, which has a trapped outlet; any leakage of wort from the cooler can thus be detected; the outlet from the box is trapped, and connected to a cast-iron pipe which takes the waste water to the bottom of the building, and delivers it outside *over* a trapped gully connected with the drains. The value of wood coolers, including the under-ribs, is about 2*s.* 6*d.* per square foot; the area of the sides and ends are added to the bottom.

Refrigerator.—The wort runs off the coolers on to this machine, where it is cooled to the temperature required. Lawrence's patent vertical refrigerators are the most suitable and efficient; the quantity of water required is about 2 barrels to 1 of wort cooled, assuming the water to be at about 54°. The whole of the wort should be cooled in one hour. A trough

collects the wort at the bottom, and is fitted with a valve and pipe to let it down to the fermenting tuns; a waste plug, washer and pipe is also provided for washing out; the waste water may be carried into the same waste box as used for the coolers. The refrigerator should be hung on trunnions for facility of cleaning; when possible the depth should be made more than the width; the wort not only cools better and quicker, but is better aërated, which is an important matter. The pipe to take away the wort to the fermenting tuns is of copper, 3 inches diameter, tinned inside and outside; the waste water pipe may be 2 inches diameter and made of wrought iron.

Fermenting Tuns.—The tops of these vessels are fixed, leaving a space of about 12 inches between them and the bottom of the refrigerator; they are made of fir; the beer is fermented in them, where it stays several days, according to circumstances. There are three of these vessels, each 6 feet 3 inches diameter by 5 feet 9 inches deep; the contents, at 4 feet 6 inches—the working depth—is 22 barrels each. They are fitted inside with attemperator coils made of copper, for the purpose of regulating the heat of the beer during fermentation. The coil is $1\frac{1}{2}$ inch diameter, and 30 feet long, and is attached to the sides of the tuns near the bottom. A connection is made between the 3-inch copper pipe from the refrigerators, and each of the

tuns. A run-off pipe and cock is provided for each tun, also a wash-out plug and washer connected with the waste water pipes. The skimming may either be done by hand, or by a parachute sliding through a stuffing box fixed in the bottom of the tun; in this case the yeast drops direct into the yeast back, hereafter named.

A yeast back is placed under the tuns, leaving a space between their bottoms and the top of the back of about 4 feet; it is made of slate $1\frac{1}{2}$ inch thick at the sides and bottom, the size is 7 feet by 6 feet by 2 feet deep, it holds 12 barrels. An outlet plug and washer is fitted at the bottom; the outlet washer has a screwed nose to which an india rubber hose is attached. A copper attemperator and hot and cold liquor supply should be provided to regulate the temperature.

The value of the wood tuns is about 12*s.* per barrel, including the yeast boards; and the attemperators, cocks, &c., 20*l.* each set.

Racking Back.—This is placed on the ground floor with proper headway between it and the tuns; the beer is run out of the tuns when finished, into this vessel, from which the casks are filled; it is made of slate 2 inches thick, and is 8 feet by 8 feet by 2 feet 3 inches deep, and holds 20 barrels. The bottom is placed about 3 feet above the floor, to allow the beer to be run out into the casks. Two or more cocks and hose are fitted at one side to run off the

beer, and a waste plug and washer for cleaning out. The value of this back is about 21*l.*, including the fittings.

Malt Machinery.—The malt is pulled up to the top of the building by sack tackle gear, and is put into a wood hopper made with a conical bottom, holding enough for one brewing; it is let out through a valve or slide at the bottom and then falls to the malt rolls, where it is screened and ground, and is then let down into a wood grist case placed over the mash tun. A valve is fitted at the bottom of the grist case, also a shoot to convey the grist to the exterior mashing machine.

Sack tackle.—This is placed near the roof at the malt store; the barrel should be 9 inches diameter by 24 inches to 30 inches long to coil about 30 feet to 35 feet of rope; it is fitted with double cone gear and break strap lever, and a rope to start and stop as required. It is driven by the shafting from the engine to give a speed to the rope of 150 feet to 200 feet per minute. The value fixed complete is about 30*l.*

Malt Rolls.—These are made of cast iron, and consist of two rollers 6 inches diameter by 12 inches long, set in a cast iron frame; they are capable of grinding 5 qrs. per hour. A screen is fixed over the mill, in which the malt is cleaned before entering the rolls. The speed of the rolls is 190 revolutions per minute; the dust is taken away to a shoot

placed under the screen; all the apparatus is enclosed to save any dust flying about the place. Proper gear must be provided to regulate the quantity of malt let down on to the rolls. The rolls are driven off the shafting by a leather band on to a fast and loose pulley. The pipe or spout delivering the ground malt or grist, either to the grist case direct or to an elevator, should be set at an angle of 60° at least; a round copper pipe makes the best shoot, as the grist falls freely in it, in square shoots the grist is liable to hang about the corners and to stop the free delivery.

The screen over the rolls should be made with wires 7 per inch; the stone screen $\frac{1}{4}$-inch wires, and $\frac{1}{4}$-inch space; the angle of the screen about 35° to 40°, a slight forward and backward movement is given to it, to facilitate the work and keep the malt running over in an equal stream. The value of the rolls, screen, dust box, and casing is about 35*l.*

The weight of a quarter of malt is 3 cwt., and the space occupied is 10·24 cubic feet, when ground 12 cubic feet; a bushel = 1·28 cubic feet.

Malt Hopper and Grist Case.—These are made of deal, and lined with $1\frac{1}{4}$-inch boards; the bottoms are made conical at an angle of 50° to 55°; the malt hopper may be left open at the top; the grist case must be closed. After the malt is ground, great care must be taken to keep all vapour or damp of any kind away. The capacity for malt is 10·24

cubic feet per quarter, and 12 cubic feet for grist or ground malt. There are some instances where it is more convenient to place the malt rolls on one of the lower floors, or on the ground floor, instead of on the top floor; when this is so, the grist is raised to the top of the grist-case by means of an elevator. The value of wood cases and hoppers is about 25*s.* to 30*s.* per quarter.

Elevator.—This consists of an endless belt, on which are fixed small buckets made of tin plate; they are fastened to the strap by copper rivets, and are placed 14 inches apart; the belt passes over pulleys at top and bottom; the top one is driven at a speed of 55 revolutions per minute; this gives a speed of 200 feet per minute at the belt. The diameter of the pulleys is 14 inches, and 5½ inches wide; the belt is 5 inches wide. The whole is enclosed in a casing of wood or cast-iron plates, and is made dust proof; the delivery shoot where it falls from the head of the elevator into the top of the grist case, must be at an angle of 60°; this shoot may be a copper pipe. The value of the elevator, if made with cast-iron legs and not exceeding 20 feet centres, is about 25*l.*, fixed complete.

Boilers.—There should be two of these (one a duplicate); these supply steam for the engine and the boiling coils, &c. Each should be 5 feet diameter by 15 feet long, and 27 inch tube, of the Cornish type set in brickwork. A feed-water heater, steam

feed pump, and injector should be provided, and the fittings named at p. 159. The boiler house should take the two boilers and leave room for coal store at one side of them. A space of at least 8 feet must be left in front of the boilers for stoking, and room for the connecting flue at the back; both of the boilers can go into one shaft. The height of the shaft will depend upon the position, about 70 to 75 feet will usually be sufficient, it should be made circular in shape and lined with fire bricks for the first twenty-five feet from the ground line.

Engine.—This should be placed as near the machines to be driven as possible, preferably in an enclosed room. The size required to drive all the machinery is one with a cylinder 8 inch diameter by 16 inch stroke; it should be of the horizontal type, and run at a speed of 80 revolutions per minute, with steam 40 lb. per square inch. No feed pump is required. It must be set on a good brickwork foundation, resting on Portland cement concrete, and have a stone 12 inches thick at the top. A leather belt 5½ inches wide is taken off a pulley 2 feet 6 inches to 3 feet diameter, keyed on the crank shaft, which gives motion to all the shafting and gear.

The Shafting must be 2½ inches diameter, and the pulleys of suitable sizes to the machines they have to drive; the width of the belts should be—malt mill 4 inches, pumps 4 inches, elevator 3 inches, sack tackle 4 inches. The bearings must not be more than

7 feet apart; all the shafting should be turned to Whitworth's standard gauge, and the pulleys and wheels bored out in the same way; in the event of having to put on any extra wheels at a future time they will be sure to fit the shaft. Steel collars must be provided at each bearing, also needle lubricators.

Well Pumps.—In places where a separate well is sunk at the brewery, a set of pumps must be placed in it; they will be worked off gear from the engine; the pumps, &c., are similar to those described at p. 121; the size in this case will be 4 inch diameter by 12 inch stroke, and the speed 40 revolutions of the crank per minute. The water is pumped from the well direct into the cold liquor back placed on top of the brewery. Fresh water is pumped up for each brewing. The rising main of the pumps should be copper, tinned inside and outside, 4 inches diameter jointed at every 9 feet, with gun-metal faced flanges, and bolted with gun-metal bolts and nuts. At the top of the rising main a copper air vessel of ample size should be provided; this takes off any shock from the pipes.

The Pipes and Cocks, &c.—All the liquor pipes, both hot and cold, for brewing, also all the wort and beer pipes, should be made of copper tinned inside and outside. All the washing water and waste pipes may be wrought or cast iron as convenient; all sizes of and under 2-inch diameter are made in wrought iron

and screwed together. The copper pipes should be put up in lengths not exceeding 8 feet long, and must be connected by unions to the cocks and various apparatus; this is for the purpose of taking down and cleaning when necessary. All the cocks should be of gun metal, solid bottom, and packed glands; each cock must have a spanner pinned on to it. The steam pipes are wrought iron, 2 inch diameter to the coils, and $1\frac{1}{2}$ inch to the engine; proper cocks must be provided to shut off where necessary, and condense boxes at the boiling coils and other places to keep the pipes clear of condense water. The value of copper pipes 2-inch diameter = 3*s.* 6*d.* per foot, and 3-inch diameter 5*s.* per foot, fixed. The value of wrought iron pipes fixed complete with all bends, and other connections as well as stays, is—1-inch diameter 8*d.* per foot, $1\frac{1}{4}$-inch 9*d.*, $1\frac{1}{2}$-inch 10*d.*, and 2-inch 1*s.* 4*d.* per foot. Cast-iron faced flanged pipes with drilled holes fixed, 3-inch = 4*s.* 6*d.* per yard, 4-inch 6*s.* per yard.

Hop Press.—The hops are usually boiled twice; when spent they are put into a screw press, and the moisture squeezed out, leaving a dry cake. The cylinder of the press is 24 inches diameter by 30 inches high; 60 lb. of hops can be pressed at one time in this machine; it is worked by hand. The press should be placed close to the hop back. The dried hops can be put on the land; when not wanted there they must be burned in the boiler or copper

furnace. The dried hops weigh about 8 lb. per cubic foot.

Yeast Press.—The yeast is pressed in one of Johnson's (of Stratford) patent presses—a No. 1 machine will be sufficient; it contains six chambers $13\frac{1}{2}$ inches square; the force pump can be worked by hand. The drainings from the press are received into a copper vessel placed directly under it; the residue or cake is about 1 inch thick; it can be put on the land. The yeast is stored in a slate tank; it must be kept in a cool place, and free from vapour, dirt, and smoke; the tank should be made with a water jacket all round it, which acts as an attemperator.

Cellar or Stores and Cask Machines.—After the beer is put into the casks, they are lowered into the cellar by a balance lift, which works automatically. An endless chain machine raises the cask as required; the men roll the casks of beer to the foot of the machine in the cellar, and as the horns or cradles which are attached to the chain at intervals come round, the casks are carried up to the ground floor level, where they roll off on to rails which are placed there to receive them. This machine is driven by power from the shafting. A small ram hydraulic lift may be used for this purpose if preferred, and worked by a fall of water from the top tank of the building; a full description of this machine will be found at p. 75. A barrel of beer weighs $4\frac{1}{4}$ cwt.

Cask-Cleaning.—A shed must be provided for cleaning casks; at one side of it a trough is formed in the floor; a cask-cleaning machine is fixed across it; in the centre of the bridge piece, a gun-metal perforated hollow cone is fixed in connection with pipes running through the bottom of the bridges. Hot water is let into the cone, to partly fill the cask, the hot-water cock which is attached to the pipe is then closed, and the steam cock opened for a fixed time; the water by this means is well roused in the cask and boiled. After the steam is shut off, the casks are rolled farther on the trough and there drained; when empty, they should be stacked in a shed to thoroughly dry.

Hot Air Apparatus.—Casks may be dried by hot air if desired; it is very advantageous to adopt this system; the temperature used is about 350°; the casks are thoroughly purified, perfectly dried, and the pores of the wood are closed; the beer is kept in much better condition, the dry state of the inside of the cask keeps it brisk. The process does not damage the cask in any way. If casks are used wet they often contain 2 to 3 lb. of water. The cleaning of casks in a proper manner is a most important thing in a brewery, and on this mainly depends the good condition of the beer and its keeping qualities.

The cost of the buildings and plant as above described is about 3500*l.* to 4000*l.*; the value of labour

and materials at the place will of necessity somewhat influence the cost of construction.

In the above description of a small brewery, suitable for the purpose under consideration, many things that are requisite in a trade concern have been omitted, as they are not required here. Only an outline of the brewing process is given, because the working of the place is always in the hands of a man accustomed to this sort of work; the small details of brewing given are only intended to guide the architect in making his design, and in laying-out the plant. Anyone requiring further details for breweries of a larger size is referred to the author's book upon 'Breweries and Maltings,' E. & F. N. Spon, London.

CHAPTER XIII.

ELECTRIC LIGHT PLANT, ELECTRIC TELEGRAPH. BELLS, &c.

Electric Light Plant.—As great advances have been made in the use of the electric light for large buildings, it is probable in many instances it may be preferred to gas. It offers many advantages: it is clean, reduces the risk from fire, and gives much less heat than gas, added to this it does not do any damage to the rooms or furniture. It is specially advantageous in lighting chapels and other large meeting rooms; it can be instantly lighted and extinguished, and in the event of a fire occurring does not help to increase it in the same way that gas would. It is rather more expensive to use than gas, probably about one-fifth more in a public institution; in many cases this would not be prohibitory when the many advantages are considered; in some places the cost would not be much more than gas; it, however, depends upon many circumstances due to particular localities. It is better to be on the safe side, and not allow the clients to suppose the light will cost less than gas, when the actual working may probably show a slight increase.

Boilers to supply steam to the engines are placed

in a house near at hand, but not attached to the engine-room. Ample boiler power should always be provided, so as to have a reserve of steam ready for any emergency that may arise. It will be necessary in most cases to put down a plant for producing the electric light; the number of lights likely to be required must be ascertained, and a margin of about 20 per cent. allowed; the electric current is produced by dynamo-electric machines, driven by engines at a high speed. It is advisable to put the plant down in sections, so as to be able to light up part of the place, if required, thus only running a section of the machines; the plant must be provided in duplicate, and so arranged that, in the event of any breakdown of the engines, &c., one of the duplicate machines, which should always be kept running slowly, can be put on immediately. As the working of the light depends upon the perfection of the machinery in action, great care must be used in the selection of suitable machines; to aid the architect in this respect, the names of reliable firms who undertake this kind of work are given. With regard to the position of the rooms for the machinery, care must be used to place them as conveniently near as possible to the place to be lighted; the construction of the rooms and the foundations for the machines also requires careful attention; this is described in detail hereafter. In some large towns, public companies supply the electric power at a fixed rate, for large places possibly at about equal to gas at 4s. per

thousand cubic feet. When, however, the number of lights required is about 400 to 500, it will always be cheaper to produce the power by putting down plant for the purpose.

Plant.—The boilers should be placed in a separate house or room; they should be in duplicate; the room should not communicate with the dynamo and engine room, it being necessary to keep the latter cool and free from dirt and dust. The engines and dynamos should be put into a room well lighted and ventilated, and kept quite free from steam and vapour; if possible, this room should be in a separate building. A plant suitable for 1000-16 candle-power lights will now be described; the most suitable boilers are those made by the Babcock & Wilcox Company, of the water-tube type.

The dynamos should be the continuous-current type, the chief and most reliable makers of which, as well as fitters of electric light plant, are Messrs. Siemens Brothers, Messrs. Crompton & Co., Limited, Messrs. Holmes & Co., The Edison and Swan United Electric Co., Messrs. Mather & Platt, Messrs. Paterson and Cooper. In choosing the firm to carry out the work, efficiency should be considered before cheapness; it will be of great advantage to distinctly specify what is required and the manner of doing the work, in order to obtain uniform estimates.

Boilers.—The power required will be about 50 horse-power nominal for 1000 lights. A duplicate

boiler must be provided. The best description for this purpose are the "Patent Water Tube," made by the Babcock & Wilcox Company, New York and London. The pressure of steam required is from 90 lb. to 100 lb. per square inch. The nominal horse-power of the boiler is taken at 1 cubic foot of water evaporated per hour. If the coal is Nixon's navigation, 1 lb. will be used to 10 lb. of water evaporated.

The boilers are set in brickwork, and have large fire grates, which can be fitted with Juckes' smoke consuming furnaces when it is desired to use small coal. An extra-sized steam chest is required to obtain the steam dry and to afford a good reserve. The space taken by two boilers is 12 feet wide by 17 feet long, and 12 feet 6 inches high; this latter dimension may be somewhat modified to suit special cases. These boilers can be worked to a high pressure with perfect safety; the tubes are tested to 350 lb. per square inch. The circulation of the water is very rapid through the tubes. There is no danger of any of the tubes bursting; they never explode, but only crack if damaged; in the event of this occurring the water running out from them would soon put out the fire. The boilers are constructed in small parts, and can be applied when other kinds of boilers could not be got in. A feed water heater, steam feed pump, one injector, and the usual fittings for ordinary boilers must be supplied.

Steam separators are placed either in the boiler or engine house to keep the steam free from water.

All the steam pipes and all parts of the boiler exposed must be covered with Le Roy's non-conducting composition.

These boilers steam rapidly, are most efficient in their action, and economical in fuel; added to which, even at higher pressure than that named above, they are absolutely safe.

Engines and Dynamos.—The best system is to apply the driving power direct, that is, to connect the crank shaft of the engine directly to the shaft of the armature of the dynamo. The engines have to run at a high speed, and are of a special kind, as hereafter described. Two sets of machines will supply the number of lights wanted, and two sets will be necessary as duplicates. It is advantageous to use two sets of machines capable of supplying 500 lights each, because there are times when only part of the lights are wanted; it is then more economical to use a smaller machine. The room in which the dynamos are placed must be well lighted and well ventilated; it must not be placed next the boiler house. The machines must rest upon brickwork foundations *entirely independent of the walls or their foundations*—they must be entirely isolated. The floor round the machines should also be free of any contact with the walls. The height of the room need not exceed 10 feet to 11 feet, and the size 20 feet by 18 feet wide. The walls are built in brickwork, and plastered inside; the room may either

have a ceiling or be made with an open roof in the same way as an engine house.

The Engines of each set should be Willan's patent two-crank tandem compound, G size; the low pressure cylinders 14 inches diameter by 6 inch stroke; they are worked by a pressure of steam of 90 to 100 lb. per square inch, and run at a speed of 450 revolutions per minute. The crank shafts are steel. The fly-wheel is placed *between* the engine and the dynamo, immediately outside the end crank bearing; the wheel is small in diameter, but heavy in the rim; it must be turned all over, and be perfectly balanced. All parts of the engines except the cylinders are enclosed in a box or tank. The shaft of the dynamo armature is also of steel; it should be 3 inches diameter. The length of all bearings must be $3\frac{1}{2}$ to 4 diameters. On the end next the engine a solid half coupling is forged on; this fits into a recess of the same diameter as the flange of the coupling in the centre plate or web of the fly-wheel, and is secured by six 1-inch diameter turned steel bolts and nuts. The engine must be carefully governed by a mechanical as well as an electric governor; the engine will indicate 75 horse-power. The steam used is 27 lb. per indicated horse-power. For every ten lights of 16 candle-power one indicated horse-power is required.

The Dynamos are placed on the same cast-iron bed plates as the engines; they may be Messrs.

J. H. Holmes & Co.'s make, to give about 300 ampères and 112 volts. Each machine will supply 500 sixteen candle-power lamps. The construction of the dynamos need not be entered into in close detail, except to point out some very essential things that must have attention. The armatures of the machines should be perfectly balanced, and made to run true between the poles of the magnets; there must be no vibration, or the working power will be materially diminished. The dynamos and engines should be railed round to prevent any interference with them.

Messrs. Holmes & Co.'s machines are made with best annealed wrought iron magnets, which give 60 per cent. more than cast iron of equal size. The commutator bars should be insulated with mica $\frac{1}{50}$ of an inch thick. The depth of the coils upon the magnets is about one-third the thickness of the iron core. Dynamos of this kind give 85 to 90 per cent. efficiency. The four machines should be set in one line, with room to move all round them; canvas covers must be placed over those not at work, and great care must be used to keep dirt and grit out of the rooms. The engines and dynamos must be bolted to brickwork foundations; oak frames are placed directly under the iron bed-plate; the brickwork must rest upon Portland cement concrete; if the machines are near any main building, special arrangements must be made in the foundations.

The speed of the armatures at the periphery is from 3000 to 3500 feet per minute.

The "positive" wire is the one leading to the lamps, the "negative" is the wire returning from the lamps. The "circuit" denotes the path of the electrical current out and home again.

A switch or distribution board, made of slate, must be placed in the room, to which all cables from the machines are connected; from this board the distribution to the various parts takes place. The board must be so placed that it is accessible at the back, but protected to prevent any interference with it.

Instruments to measure the current are placed on the walls of the room; a speed indicator is attached to each machine; the maximum speed given to the attendant must not be exceeded; and, in case the governors do not act when any large number of the lamps are switched off, the man should be at hand to control the engine.

The cables must be run in a closed box or pipe sunk in the ground, the "positive" and "negative" cables being kept separate; great care must be taken that nothing interferes with the insulation, or that any part of the cables are exposed where they are liable to injury. Holes are formed at certain spots, and are fitted with iron frames and covers for examination of the cables; damp and wet must be kept out; the examination covers must be locked, and every precaution taken that no damage can be done to the cables or their connections.

Wiring in the building.—This must be conducted

with great care; the "positive" and "negative" wires may be run in the same wood cases, but carefully separated; the diameter of the wire depends upon the length the current has to travel, and the number of lamps to be supplied; it is advisable to make a provision in the contract for extra wiring, or for increasing the diameter of the cable if found necessary.

Lamps.—All the inside lamps should be "incandescent," and from 12 to 16 candle-power each; the latter, of Edison's make, take 0·73 of an ampère to supply each. Larger lights are provided for the chapel, meeting, and other large rooms, of say 50, 100, and 200 candle-power; about one indicated horse-power is required for 160 to 200 candles. At each "incandescent" light, or at each set of lights, as required, a switch is fitted, also a safety fuse; in case the wire gets too much heated by an increased current, the fuse melts and saves an accident. In proper places along the main conductor or wire, resistances are provided which take up the current when any number of lamps are shut off at one time. The temperature of the wires should not exceed 150° F. Safety fuses should melt and break when the safe working current is exceeded by 50 per cent.

The cost of incandescent lamps is about 4*s.* each when taken in large quantities; they last from 1000 to 1200 hours in work, in some instances they have

lasted 1370 hours. The "Swan" lamps, of 16 candle-power each, take 60 watts at 100 volts, consumption is 0·6 ampères.

Area of lighting.—A 16 candle-power lamp will light about 8 feet diameter at 8 feet high from the ground; in ordinary places one lamp for each 38 square feet is sufficient. A room 33 feet by 21 feet can be well lighted by twelve 16 candle-power lamps.

Candle-power is compared to sperm candles consuming 120 grains per hour.

Arc lights are only suited to exterior lighting; one indicated horse-power gives a light of 1500 candles; the "arc" lights cost much less to produce than "incandescent," but are not so convenient for use; the latter are more steady. When the light required in any one lamp does not exceed 250 to 300 candle-power, the incandescent are the best to use.

Arc lights outside.—One of 2000 candle-power will light 2800 square yards; for inside lighting one for 730 square yards. Crompton's patent lamps with 13 mm. diameter by 19½ inches long carbons will burn 12 to 16 hours, according to the current. The electromotive force = 50 to 60 volts. Messrs. Siemens Brothers, also Messrs. Holmes & Co., make suitable "arc" lamps. Great improvements have been made in these lamps lately; they now burn very steadily; some of them are, however, rather liable to be blown out in high winds.

The engines and dynamos may stop working at 10 o'clock at night; after this time the current can be supplied by means of secondary batteries (sometimes erroneously called accumulators). A battery to operate 25 sixteen candle-power lamps for five hours each night = 1250 lbs. weight; the efficiency is 90 per cent. of the current used to charge it. The loss through the cells, if they stand a maximum of fifteen days, is about 7 per cent. The cells are charged in the day time, and from them the current is taken to the lights after the engines and dynamos have stopped. In very large establishments, where the light is required later in the evening, it may be necessary to run the engines longer than that named above. The weight of the battery required for *each* lamp for *each hour* of burning is 10 lbs. It will be understood that lighting from batteries is more expensive than taking the current direct from the cable from the dynamos. "Planté's" are the best batteries to use; they are reliable and do not require very much attention.

The coals used would be about 200 lb. per hour, or say 2 to 2½ lb. per boiler horse power.

Labour.—Two men are required to attend to the machinery, one for the boilers and one to attend the engines and dynamos; the former may be an ordinary stoker, the latter must be a good mechanic, experienced in electrical matters, under whose charge, subject to the orders of the resident engineer, all the plant, lamps, and wiring should be placed.

Power may be taken off the cable to drive small machines, such as sewing machines, dairy machines, or any other light work. Allowance must of course be made for this in the power of the engines and dynamos.

The cost of a plant, including the wiring, plain brackets, and lamps, will be about 3300*l.*; this is calculated upon the number of lamps, viz. 1000 × 16 candle-power each = 16,000 candles. In estimating the indicated horse-power required, where larger lights are used, the light given must be reduced to a standard of 16 candle-power. The above cost does not include "arc" lamps for outside lighting; they vary in price according to their power and the maker.

The buildings and foundations for the plant may be erected for about 800*l.*; they need only be of a plain character suited to asylums, &c.

Leading particulars have been given to afford sufficient information to the architect as to what is the best system of installation for plant. The subject of electric lighting is too extensive and complicated to fully treat in the limits of the space at disposal in this book; a few leading data have been given necessary to understand; electrical technicalities have been avoided as much as possible, with a desire to make the matter clear and plain. In any large installation of this kind the architect would no doubt think it advisable to seek assistance from a consulting engineer who has had special experience in this branch of practice.

It may be useful to know some of the electrical terms and their values; the chief of these are given below:—

"Ampère"—the rate of flow or delivery of the electricity.

"Volt"—the measure of pressure of the electromotive force.

"Watts"—ampères × volts.

"E.H.P." = 746 watts.

"Ohm"—measure of resistance, volt ÷ by an ampère.

One ampère per second = 1 coulomb.

One farad unit of capacity, 1 coulomb ÷ by 1 volt.

The Resistance of annealed iron wire is six times as great as copper; and that of German silver is thirteen times as great as copper.

Electricity up to 100 to 110 volts pressure, is not at any time dangerous to life; but a very uncomfortable shock can be received from dynamos or from cables and the wires, if any one places two hands upon them, especially if the hands are damp, and the person is standing upon iron plates. No one but the attendant should be allowed in the room, not only on account of personal injury that may occur, but also the damage that may be done to the machines. The cables and wires in the building should be placed in wood or iron cases, and no one on any pretext should be allowed to interfere with them.

Electric Bells.

These are very suitable for a large establishment; they are worked by small batteries placed out of reach; the best kind are Leclanché's. It is better not to take too many bells off one set of batteries, but to distribute them in sections, each set being worked by its own battery. The "buttons" for working the bells and the wires to convey the current are of a very simple character. An indicator board is provided in all the chief places where it is required to make communication; when any bell is rung, a signal is thrown out on this board, indicating the number or name of the room. The wires are carried in wood or metal cases; they are placed where they cannot be interfered with. The "buttons" or bell operators are also placed where only the attendants can use them. Several firms make a speciality of these; the author has found Messrs. Edmondson & Co. and Messrs. Strode & Co. suitable firms and on whom reliance can be placed. It will save the architect much trouble if he consults one of them and makes the necessary arrangements for the wires according to their regulations when the place is being built. It is a simple matter to fit them up, but very important that only reliable firms should be employed, to ensure their successful working; when the work is done indifferently it causes endless trouble and annoyance.

Fire alarms can also be worked by the electric wires in the same manner as the bells.

Electric Telegraph.

It is an essential thing to be able to communicate messages to the different departments of the building, especially in case of any sudden emergency. In some cases the communication may be made by a code of signals by prearrangement by the number of strokes on the bell; in other cases, an ordinary alphabet instrument may be used. The wiring of the telegraph should be free from all other wires; the perfect insulation of the wires is a matter of moment. The several places to be put into communication must be decided by the authorities of the institution.

The telegraph is not so much used since the introduction of telephones; these latter instruments are best suited for public institutions.

Messrs. Siemens Brothers undertake this work and carry it out in a first-class manner.

Telephones.

These are a suitable means of communication in many cases, especially between certain departments where there must be no uncertainty as to the order given, or who is giving it. It must be borne in mind the telephone has this great advan-

tage, the voice of the speaker can be perfectly distinguished, as well as the message being clearly heard as it is spoken. The following are suitable places for these apparatus :—From the wards to the kitchen; to the superintendent; to the doctor; to the resident engineer; to the electric plant room; to the gas works; to the storekeeper: from the engineer to all the above departments; also to all the engine rooms, laundry, brewery, and workshops.

As these instruments are of a very special character, they must be placed in the hands only of those who have had special experience in such things. They are of necessity somewhat expensive; the number will, therefore, depend upon the outlay that can be allowed, governed, of course, by the exigency of the case.

Speaking Tubes.

A very ingenious combination of the usual speaking tubes and electric wires has been introduced and is made by Mr. George Jennings; by its means the speaker can communicate with one room alone, so that only the person can hear for whom the message is intended. They are very useful for messages from room to room when they are near each other. The tubes should be made of zinc; as a rule, messages cannot be conveyed with advantage beyond 200 feet. The mouth-pieces for the electric system are of a special character. Sets of these tubes should be placed in the engineer's room to send messages close to his

office. On taking up the mouth-piece in any room, an electric bell is sounded at the terminal; the bell is stopped directly the mouth-piece is raised in the other room. All the other tubes are closed by means of simple valves during the time a message is being conveyed to the room in communication. It is a very simple contrivance, and one that should be adopted when speaking tubes to various points are required.

INDEX.

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